MASTEROPPGAVE

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Becoming Trapped: An Inquiry into Life, History, and Human Nature

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I. Abstract

I argue that when considering our species' current ecological situation and our "inability" – behaviorally – to deal with its precariousness, we must look beyond the typical reasons found within our psychology, and instead apply a broad evolutionary framework for analysis.

Accordingly, to stay true to my own suggestion I have analyzed our species behavior (individually as well as collectively) in light of the first principles derived from the theoretical concepts of biological evolution, complexity theory, and thermodynamics.

My conclusion is that our behavior and resistance to change, in general, lies outside the boundaries of true "agency" and, instead, is deeply embedded within our evolutionary history and the relationship between energy, complex system dynamics, and the second law of thermodynamics.

II. Contents

III. Illustrations

FIGURES

TABLES

IV. Acknowledgements

First and foremost, I must begin by thanking my "partner in crime" Nicole for your endless support, critique, and patience on this challenging endeavor which at times has been, to put it mildly, rife with frustrations, "dead-ends", and near give-ups – but nevertheless fun!

Secondly, I would like to thank my teachers Ove Jacobsen, Stig Ingebrigtsen, and Øystein Nystad in *Ecological Economics* at Nord University in Bodø, which throughout the course has challenged (dare I say) us to not only think outside the normal confinements of our society but also the importance of integrating both science and philosophy.

And finally, I am forever grateful to all those scientists, theorists, and "thinkers" whose shoulders I have been standing on. Had it not been for these people's tireless work and effort – which by far surpasses mine – this thesis would have never seen the light of day. As there is no room for all, I will honorably mention those whose work has inspired me the most: Carl Sagan, Dorion Sagan, Lynn Margulis, Eric D. Schneider, Harold Morowitz, Eric Chaisson, Nate Hagens, and David Korowicz – Thank you!

WARNING!

This author is neither a scientist, a theorist, nor is he a physicist and certainly not a biologist – he is not even trained as an economist (although he does work in the financial industry).

I am, however, highly curious – and I do enjoy a great "puzzle." And what greater "puzzle" than "ourselves"…

V. Method: A Bird's-Eye View

Any investigation, whatever it is – a crime, a plane crash, or just pure curiosity – requires some kind of platform, or framework, for analysis. My inquiry proves no different. So I will provide you with a theoretical one (as this thesis is neither in the qualitative nor the quantitative domain), loosely based upon the basic principles found within Systems Science. And by loosely I mean that, while I will not follow the method of Systems Science per se, I will still use its overarching principle as a *meta*science [1]: to analyze, observe and discern patterns in ways that are both unifying and explanatory. This, of course, will be done in a "bird's-eye view" (i.e., focusing on first principles) rather than a detailed deep-dive – that is just the nature of an "interdisciplinary" platform such as this.

As for research material, it will largely consist of primary, secondary and tertiary sources of various scientific literatures. In essence, this means everything from journal articles, theses, and peer-reviewed articles, to academic textbooks, nonfiction science books, and encyclopedias (such as Wikipedia amongst others).[1]

So, on the face of it, this all seems fine and dandy. Here we have a seemingly solid framework not only as mode of analysis but also with regards to the utilization of research material grounded in the sciences. In fact, some of the applied literature is written by very prominent, highly acclaimed, if not pioneering scientists such as Lynn Margulis, Stephen Jay Gould and Edward O. Wilson, to name but a few.

There shouldn't then be much concern, right? All the facts and claims in this thesis can be bought at face value? No doubt about it? No questions asked? Well, I wish I could tell you otherwise, but no, that isn't the case, unfortunately. Instead, I will urge you to remain highly

[1] For those of you unfamiliar with this, here's a more thorough walkthrough: 1) Primary sources are reports of new data, findings and theories in its original form (usually published as research reports, journal articles, conference papers, dissertations and theses), 2) Secondary sources are, for example, academic textbooks, peer-reviewed journal articles, and other scientific/academic literature where information (such as other researcher's primary literature) is repeated, interpreted and assessed, and 3) Tertiary sources are sources such as encyclopedias (Wikipedia etc.), textbooks, fact books, handbooks etc., where widely accepted information (proven facts, definitions and so forth) is presented in an overall perspective.

skeptical towards the second hand references, quotes, scientific findings, interpretations and so forth, given to you by me. And here's why:

> In any type of research – whether it's in dissertations, conference papers or academic textbooks – there is always some form of analysis based upon various data, either collected by the author himself or by other researchers. Although this is not a problem in itself, it is highly unlikely that you know either the complete set of data or the method of collection, intrinsically. And even if you do, there is still the chance of data being "carefully" selected (such as omission of contradictory evidence), misinterpreted (intentionally or not) and, at worst, manipulated. Like it or not, there are in fact a myriad of psychologically rooted "mind traps" which can befall us all, even the best of us. Known as cognitive biases, these are "thinking" errors preventing you from "accurately understanding reality, even when confronted with all the needed data and evidence to form an accurate view [2]."
>
> On top of that, there is also the possibility of the author carrying a specific "agenda" that, for all intents and purposes, is governed by political and/or ideological views rather than honest and objective analysis. And this isn't just heresy, as there is indeed current evidence pointing towards a "darker side" of modern science: of various parts being "institutionalized", and thus strongly influenced by money, ideology and politics [3, 4, 5].
>
> And at last (but definitely not least), there's the use of theoretical models. Here too there are elements of "risk", especially in terms of validity, as all models are, in principle, simulations – they are built with the purpose of yielding results based upon certain assumptions (i.e., what is being modeled). We have on our hands, then, a "system" which, by design, is not only sensitive to data input but also to unknown variables[2], as well as how these are "interpreted." Models are thereby vulnerable to the principle of "garbage in, garbage out" and, as such – in accordance with Liebig's Law [6] – no better than their weakest link.

So you see, there is some truth to the words of Samuel Butler (1835 – 1902), the English novelist and a contemporary critic of Charles Darwin, who in the late nineteenth century wrote that

[2] Both of these factors are probably why models often display such a large margin of error.

scientists are “the priests of the modern age” and that they, therefore, “must be watched very closely [7].”

Now hold on! Let’s stop for a moment. What? Are you basically suggesting that scientific literature in principle is unreliable? That it cannot in any way be trusted? That there are no “facts”, it’s all just fiction?

No, absolutely not. If it comes across as such, then my apologies – that is not my intention at all. Quite the contrary, I do find scientific research to be of tremendous value, especially when properly done in accordance with the scientific method [8], or else I wouldn’t use it. In my opinion, it is by far the best way of gathering data and acquiring new knowledge as long as both skepticism and critical thinking is applied in the process.

Carl Sagan (1934 – 1996), the illustrious American astronomer best known for his popularization of science through the TV-series “Cosmos” in the eighties [9], wrote – rather elegantly – that “skeptical scrutiny is the means, in both science and religion, by which deep thoughts can be winnowed from deep nonsense [10].” And I agree with Sagan: to seek new knowledge, scrutinize the findings, acquire data, test, falsify, reject or accept the evidence, followed by the formation of new hypothesis and, at best, theories – this is indeed how science, as a whole, advances.

Yes, there will be some “nonsense” along the way when there are humans involved. And I too will definitely fall for one or more of the many mind traps of cognitive biases. I might even carry an agenda. But that’s ok. All findings – whether of scientific origin or not – are approximations of reality, anyway. It’s impossible to know all the details and facts however much we try. But science and its research is definitely the best way, if not the only way, of piecing together the puzzle of knowledge and understanding. As the aforementioned Sagan so poignantly put it: “Science is much more than a body of knowledge. It is a way of thinking [11].”

Introduction: Carnage at Sea

From pollution, deforestation, and species extinction, to famines, disease, and resource wars, when thinking about humanity's current ecological situation – one that fits the description of what population ecologist refers to as "overshoot"[3] – I am eerily reminded of the story of Titanic:

Here was a ship considered the apex of technical engineering. Assumed unsinkable, it was powerful but static – it consumed a vast amount of energy. Festive and celebrating, on its maiden journey, the "Ship of Dreams" sailed nonchalantly into unknown seas … With the boat crew's complete disregard of incoming warnings, and a prideful belief in the ship's claimed "invincibility", it was a recipe for disaster. Thus, it was not a question of IF but of WHEN the merciless forces of mother nature would swallow this arrogant vessel and squeeze the cold, damp breath out of its passengers – in what could only be described as "*the* carnage at sea." The rest, as we know, is history …

FIGURE 1 "Untergang der Titanic", Willy Stöwer 1912 (Public domain)

[3] Overshoot is when a species population exceeds its resource base.

Although a rather simplistic analogy of humanity's predicament – and let us be honest, a cliché filled one as well – ours is clearly not one of poorly designed steel, but one of excessive resource extraction coupled with overpopulation. But in a similar fashion, in what is reminiscent of Titanic's captain's costly decision [12], we too are not heeding the warnings of the ice-cold, densely packed threats looming in the horizon, whilst floating full steam ahead into a dangerous sea of resource scarcity, economic collapse and possible climate change.

> "PHILOSPHICAL FOOTNOTE":
>
> Somewhat ironically, we now find ourselves in a situation we so aptly ascribes to the so called plague species of rats, rabbits, mice, and lemmings, where the population – provided enough resources – will grow exponentially (geometric). For instance, with the current growth rate of one percent, the human population will explode from today's already crowded number of 7.4 billion souls to a staggering *20 billion in less than a century*. Now, think what a few thousand years would do, if not to talk about a million – a mere blip of geological time …

Thus, considering humanity's precarious ecological situation and our reaction to it[4], it seems like we are rushing towards extinction[5], and – like the passengers on Titanic – are somewhat powerless to stop it.

Why then, as a global unit, as the very first species on earth ever to know its ecological footprint [13], are we still pursuing this dangerous course of potential carnage?

This is my quest, my inquiry, and…my story!

[4] In my view, we are just rearranging the ship's deckchairs in order to keep the illusion of an unsinkable ship alive (does central bankers easy money policy of QE, TARP etc ring a bell?) more than we are implementing long term solutions to our growth induced problems.

[5] The fossil record is rife with examples of species disappearing after they are at their most numerous [108].

Part I: The Road to Inquiry

1. Cornucopian Confidence

Although representing the drivers behind my quest to know "why", such daunting views of collapse, disaster, and possible extinction – when looking at the human ecology – have not always resided in the gray matter of my brain. Actually, they are quite a recent phenomenon. As a matter of fact, in most of my adult life (I was born in the late '70s) I believed the cornucopian myths of endless growth, progress and prosperity, and that the laws of nature would yield to human ingenuity and our technological prowess. (Why wouldn't I believe otherwise, considering that humans had ascended from the pristine Stone Age to the technological wonders of the modern age in such a relatively short time?) The forces of war, hunger and scarcity – only felt in the less "developed" parts of the world – were distant and unfamiliar concepts in a western smorgasbord of novelty and consumption.

Hence, with beliefs aligned with this century's social metrics for success, I got myself a good education and, in 2006, a respectable profession as a stockbroker. The world became my oyster. Little did I know at that time, that a few years down the road such beliefs would be shattered by the economic upheaval of 2008 (aka The Global Financial Crisis) and an accidental acquaintance with a small resource blog called "The Oil Drum."

2. Hitting "The Drum"

Contrary to what one might expect, it wasn't the stock market crash itself (although it definitely contributed in a major way) that fractured the seemingly solid core of my belief structure, but the preceding oil price "moon shoot" (see Figure 2) in the spring/summer of '08.[6] At the time, through my daily work of

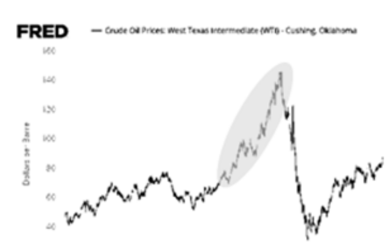


FIGURE 2 Crude Oil Prices WTI (Source: Federal Reserve Economic Data)

[6] Six months prior we had seen the beginnings of trouble for the economy with the start of the subprime mortgage crisis, which was dismissed by Ben Bernanke, the chairman of the FED, as only a minute problem [109].

buying and selling stocks, I had learned a sufficient amount of economic theory to understand the supply and demand *imbalance* part of the oil price equation thereby having a proximate understanding of what was happening. Yet somehow, intuitively, I still felt that something was missing – I couldn't quite put my finger at it. Fortunately (or unfortunately, depending on your perspective) curiosity runs in my blood. So I did what I always do when I am faced with a "puzzle": research, ponder, turn frustrated, and then research some more.

Many grueling yet stimulating months later, when casually investigating the corners of the blogosphere for potential answers, I hit "the Drum" so to speak. Now, The Oil Drum wasn't your daily "run-of-the-mill" blog of light entertainment or self-righteous gossip, but one of serious analysis and discussion of energy and its impact on society – both by current as well as former employees from the energy industry [14]. In hindsight, this was probably the point of attraction: well-grounded empirical analysis by industry insiders, which from a job security standpoint sometimes, rebelliously, bit the hand that fed them.

So I started in the archive (the blog was operational from 2005), chronologically with autistic devotion, reading every article ever posted – which translated into a binge fest of pain, disbelief, and dismissal (probably a natural reaction considering the evidence contrary to my innate beliefs). In denial, I searched for evidence that could dispute "The Drum's" many claims. I reread with anger. I even bargained with myself: "if only this and that..." Eventually, I reached the conclusion – in what would shatter the brick wall of my "rose colored glasses" (i.e., my beliefs) and plunge me into a deep existential crisis of confidence – that there were three biophysical concepts that couldn't be refuted.

3. Unquestionable Concepts

Oil's energy density, Peak Oil, and Net Energy (EROEI) – these were the irrefutable theoretical concepts that laid my old cornucopian confidence to waste. Best described as a harrowing epiphany, my layman's comprehension of these subjects was, at the time[7], entrenched in the following:

1) OIL'S ENERGY DENSITY: As a "fuel" to the engine of economic growth, oil is about as irreplaceable as it gets (but amazing nonetheless) considering the fact that one barrel of this condensed sunlight is substituting ~11 years (!) of manual labor.[8] (This is equivalent to a 190-pound human being having the strength of a 30 ton gorilla!) Thus, measured in GDP (Gross Domestic Product), in what I refer to as the unspoken "trade of the century", oil is actually subsidizing about *200 000 Euro's worth of potential labor*[9] – all bought for less than 50 dollars![10] No wonder we are so addicted to it… But there's a "catch", and a big one, too: the resource is non-renewable – once burned the "magic" is gone. Hence, the "gloomier" concept of Peak Oil.

2) PEAK OIL: The point when global oil production reaches its climax followed by an irreversible decline. Cannot be refuted because a) the earth is finite, and b) oil is non-renewable. Timeline: Only in hindsight is it possible to know the exact date of the peak, but with current extraction rate and consumption, most likely in my lifetime. Consequence: Since the economy is based on low-cost easily extractable oil, a peak in production represents future increased costs thereby halting economic growth. A shrinking economy would then culminate into a financial crisis, followed by the possibility of political turmoil, and at worst, war. The easy life of novelty and consumption reaches its endpoint. (Ouch!)

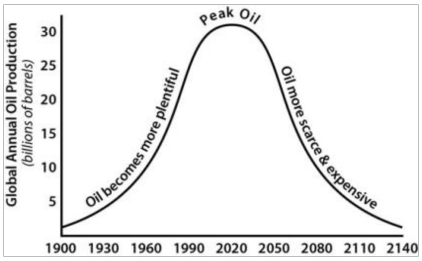


FIGURE 3 Theoretical diagram of Peak Oil production curve (Credit: Peakoil.com)

[7] I still think they are as valid as ever, if not even more. But, as the biophysical limits will materialize in the economy first (probably manifested through several financial crisis), the concepts of Peak Oil, Net Energy, and oil's "irreplaceability" will probably still reside in the dark …

[8] Let's do the math: 1 barrel of oil [110] = 5,8 mill BTUs = 1 699 kWh, daily caloric need 2 500 kcal = 2,9 kWh, manual labor ex weekend of 7,5 hours a day = 0,6 kWh a day [(2,9 kWh*7 days)/(7,5t*5 days) = 0,55 kWh], 1 700kWh/0,6kWh = 2 833 days, number of workdays ex weekend 5*52 weeks = 260, 2 833/260 = <u>10,89 years</u> (special thanks to Nate Hagens @ themonkeytrap.us for inspiring me to crunch the numbers myself)

[9] Calculated with an average income in EU of EUR 18 000 [111].

[10] The current market price for oil.

3) NET ENERGY: The technical term is actually EROEI (pronounced "i-roy"), or Energy Return On Energy Invested. This is a fancy way of saying that it requires energy to extract energy, and that the return (or the "net" gain) of this process is what is available for future work. It is as simple as that; nothing earth shattering about it. But – and this is where things suddenly gets more interesting – when "net energy" is applied to finite resources such as conventional oil, tar sands, oil shale, coal, and natural gas to name a few, the cost of extracting energy will, with time, increase in energy *terms* (you have to dig deeper and deeper into that oil-well or shale mine don't you …), eventually materializing in what is referred to as "the net energy cliff" (see Figure 4). Consequence: Although Peak Oil implies that we will eventually run out of oil[11]; net energy says that we will not. A good thing, right? Wrong! What net energy says is that once you have reached the point where it takes one barrel of oil to extract one barrel of oil (a ratio of 1:1), you are quite literally out of "gas" so to speak. It doesn't matter if there are billions of barrels left in the ground – you are just treading water. Now, this is a serious problem (or predicament…you choose) for an energy hungry modernized human enterprise which, according to estimates, requires a minimum surplus of about 5 to 8 barrels of oil in return for each barrel invested to keep itself a float (adjusting for the energy business) – a surplus that will definitely disappear! Bearing in mind that EROEI globally has declined from 30:1 in 1995 to 18:1 in 2006, we are very much dangling at the edge of the cliff [15]. (Panic mode reached!)

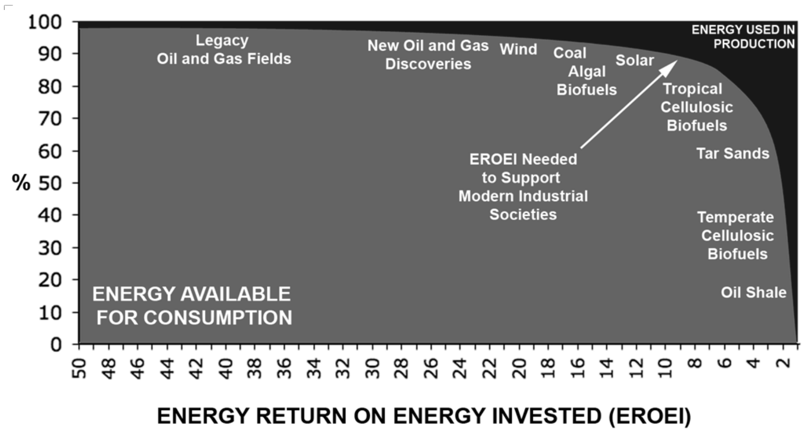


FIGURE 4 "The net energy cliff" illustrates how much energy is available for consumption on different sources of energy after deduction of extraction costs measured in energy terms (Public domain)

[11] To say that Peak Oil implies that we are "running out of oil" is clearly an overstatement and a wrongful interpretation of the concept. Peak Oil is about global oil production climax. However, since we inhabit a finite sphere, it can figuratively be interpreted as eventually running out of oil – hence my wording in this sentence.

4. Malthusian Meltdown

As Dr. Jekyll turned into Mr. Hide, the Cornucopian turned into the Malthusian.[12] And let me tell you this: the Malthusian mindset is not a pleasure filled voyage of palatial palaces and rainbow colored unicorns, but one of horror, fear, and frightfulness. Panicked and alarmed by my findings, I followed the forces of what I call "Irrational 101" – telling everyone near and dear that their future is screwed. And trust me, that didn't end well…

Here I was with my important story, a story grounded in the hard sciences, one concerning not only our immediate future well-being but also the future lives of our children and grandchildren as well, completely denied or nonchalantly shrugged at in its presumed insignificance. If even given the courtesy of finishing my arguments – usually I was interrupted mid-sentence with dismissive rebuttals such as "you're plain wrong", "stop being so negative", "many have cried wolf before", "the stone age didn't end because they ran out of stone" (typical Peak Oil rebuttal, by the way); or from the more malign ones of "get yourself a psychiatric assessment" or "if you believe this, why don't you move into a cave in the woods?" to the more polite but rare "you may have a point, but technology will solve everything so don't you worry" – the discussions always ended in a stalemate; they were seldom fruitful, if even worth having.

> "PHILOSPHICAL FOOTNOTE":
>
> Spreading what is perceived as doom and gloom is not something I recommend. It probably contributed to the downfall of my marriage (albeit there were several other more pressing reasons as well), and some vexatious discussions/debates with family, friends, and the occasional stranger. Frankly, it was neither the best time of my life nor my proudest.

After a while, being mentally drained, having fought long and hard in the "trenches of truth", I ceased the Malthusian crusade of conviction. Facts were clearly not sufficient; that much I understood. And that troubled me a great deal. It left me restless and anxious, as if I had broken the law without being caught, unsure if all my tracks were covered. When discussing the tougher matters of life and society, why on earth would people become so defensive and obtuse? And why would they argue – and persistently so – against their own long-term self-interest? Now, I

[12] In reference to Reverend Thomas Robert Malthus, who in 1798 wrote (somewhat ironically, in hindsight, as this was approximately the time when humanity discovered coal, oil and gas to power its growth) the book *An Essay on the Principle of Populations* warning against unchecked population growth. Basically, being "Malthusian" is just a pejorative term for excessive pessimism [112].

am by no means a rocket scientist or a quantum physicist, yet it was abundantly clear that I was missing a rather significant piece of humanity's precarious puzzle.

So what was I missing? Where was my blind spot? I knew the resource/oil story of our situation; I knew from firsthand experience that we don't care about the facts; that we (well, at least most of us anyway) are optimistically biased; and that we resist change – and that none of it explains the *why* side of human nature. Somehow, it felt like I was running in circles, each time a bit more knowledgeable, yet always arriving at square one.

So, in an act of frustration I determined it was necessary to change my approach. No more self-absorbed "researchathons" followed by petrifying preaches. This time around I would do it "properly" and follow a more formal route through the educational system.

5. A Lesser Degree

I landed on studying Ecological Economics – an interdisciplinary field of academic research bridging economics with ecology. As I already had some formal training in economics having a bachelor's degree in the subject (plus the fact that my part-time pondering/investigation had triggered an inner desire in knowing more about ecology), this seemed like a sensible choice.

And I must say, on the surface of it, after skimming through the theoretical material, it looked like I could be pretty darn confident that the field's priests and priestesses would peel away the secret layers of human nature and reveal the forces of *why* – despite the fact that scientific knowledge tells us it's not such a good idea – we still continue pursuing a course synonymous with extinction.

Well, it turns out that I didn't get the exposé I so badly wanted. I got more of the "what" and a lesser degree of "why." This of course disappointed me greatly; to say otherwise would be a lie. Ultimately though, it came down to my own expectations – I cannot fault Ecological Economics for this. I will, however, argue that the so-called interdisciplinarity of the discipline is somewhat limited, perhaps a bit one-sided as well. It is my opinion (one formed while studying the course at Nord University in Bodø, Norway) that, while the science of Ecological Economics has a firm grasp in understanding the relationship between natural resources, economic activity and the limits to growth (in what I would describe as the "what" part of our situation), it stands on a weaker ground in understanding the drivers behind humanity's collective behavior. Now, as a counterweight to classical economics, Ecological Economics delivers just beautifully. Theoretically, it literally destroys classical economic thought – no question about it.[13] But that is also the core of the problem. Precisely because the discipline is so good at exposing faulty economical thinking it spends a disproportionate amount of its theoretical material doing just so. Areas outside this realm – such as human behavior, amongst others – are thereby merely treated as a footnote in comparison.[14] And when behavioral aspects are given some attention, the angle usually stays an economical one, thus remaining within the fields warm and fuzzy comfort zone, resorting to short yet passionately infused refusals of classical economics' naïve view of human beings as perfectly rational, utility maximizing consumer "machines" [16].

In reaching such conclusion – i.e., acknowledging that Ecological Economics' strongpoint doesn't reside in understanding human nature – I might as well have quit. But quitting is not an option. It just isn't part of my DNA…

So here we are…now…with this thesis functioning as a "vehicle" for my relentless pursuit for potential answers.

[13] Major points being that 1) the economy is a subset of the environment and not the other way around, 2) there are physical limits to growth, 3) there are other types of capital just as – if not more – important than financial (these are natural, human, built, and social capital), 4) increased GDP does not equal increased happiness, and 5) that we now live in what Herman E. Daly describes as "a full world" [113].

[14] For instance, in *Ecological Economics: Second edition, Principles and Applications* (which, by the way, might be deemed as "the Bible" within the field) its authors, the astute Herman E. Daly and his colleague Joshua Farley, devotes well over 80 percent of the book's 481 pages in a theoretical/practical deconstruction of neoclassical economics. Human behavior, on the other hand, is treated with a meager 5 percent (25 pages).

Part II: A Road Less Travelled

6. A Personal Paradox

At this point, I do feel the need to spend a few moments on some personal thoughts – and please bear with me; I promise this has relevance – surrounding this "road to inquiry."

For in all honesty, it has been quite a tumultuous journey; not only of shattered beliefs but also one of personal discomfort, and now, self-reflection. However fascinating as it might be, I do find it somewhat troubling that I through an acquired knowledge of biophysical concepts could end up with such diametrically opposed beliefs: from "eternal prosperity" to "endless collapse." But what is more troubling is, in fact, the realization that even though my belief structure has changed, my behavior nonetheless stays the same. Yes, I do think about my own ecological footprint (which, let's be honest, as an upper middle class western citizen far exceeds the global average), and at times – quite many, actually – I do feel guilty about it. But I also feel kind of "locked-in": too tempted to consume, to seek novelty and entertainment, and to reproduce – behavioral traits that downright trump the ecologically "conscious" mind of mine. Knowledge and facts are clearly not sufficient in my case either, and that to me is a paradox of personal mystery.

However, in the context of the global community of humans, this personal "mystery" somewhat dissipates: here my "behavior" is far from unique; as is I holding "beliefs." Indeed, to me it seems as if all humans, although in varying degrees, possesses some kind of belief structure – either in the form of religious dogma of us created in the image of an intelligent designer, a deity, a God, or the opposite but no less myth-based environmentalist belief in our "destructive tendencies" as posing a threat to all life on Earth, or a belief in science, social Darwinism, sustainability, renewable energy, technology, economical growth, market forces, ghosts, tarot

FIGURE 5 "Creation of Adam", Michelangelo circa 1511 (Public domain)

cards, green fairies; whatever it may be – and which belief, or multiple beliefs for that matter, that is held differs (with the exception of "beliefs" induced by psychiatric disorders) on the basis of cultural origins and close environmental variables (i.e., where you are born, your parental upbringing, your education, your family, your friends, and your different group affiliations and so forth).

Nevertheless, the imperative still stays the same: in aggregate we continue to grow, consume and reproduce. Yes, there are monasteries filled with nuns refraining from sex and reproduction; and yes, there are small ecologically "stable" societies in various parts of the world. But in the greater scheme of things such marginal differences amounts to nothing, at least when looking at historical data of population growth and our insatiable demand for natural resources (see Figure 7). In fact, current scientific evidence, although not entirely conclusive [17], suggests that extinction has followed in the footsteps of mankind for several millennia [18, 19].

Now, this is quite interesting. If this is true, that extinction correlates with human migration and that it has been so in all of human history, it signifies that there is absolutely no certainty that we can "think"[15] our way out of this precarious fossil energy induced overpopulation trap of ours, which, by the way – according to scientists – is the sole reason behind the current sixth great extinction event on our planet [20]. In fact, what it infers (in my opinion) is that it all sort of naturally "happened" without us consciously choosing so, and that, as such, there may be other forces at play, forces that are not necessarily overridden by "thought" and "consciousness", and that we in all probability live in a world that maybe works somewhat differently than we would, actually, *like* to think.

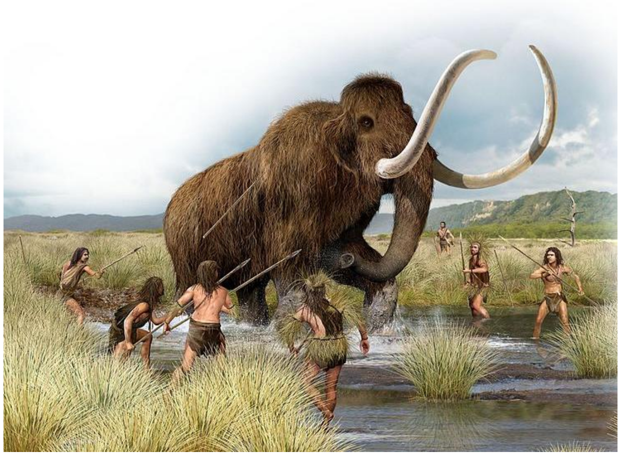


FIGURE 6 Group of indigenous people hunting a Wooly Mammoth [114]

[15] For example, by globally applying knowledge from the various types of social sciences – such as anthropology, psychology, sociology, behavioral economics and, yes, ecological economics as well, to name a few – via the political body of reforms and regulations etc. as to gain traction for long term global "sustainability."

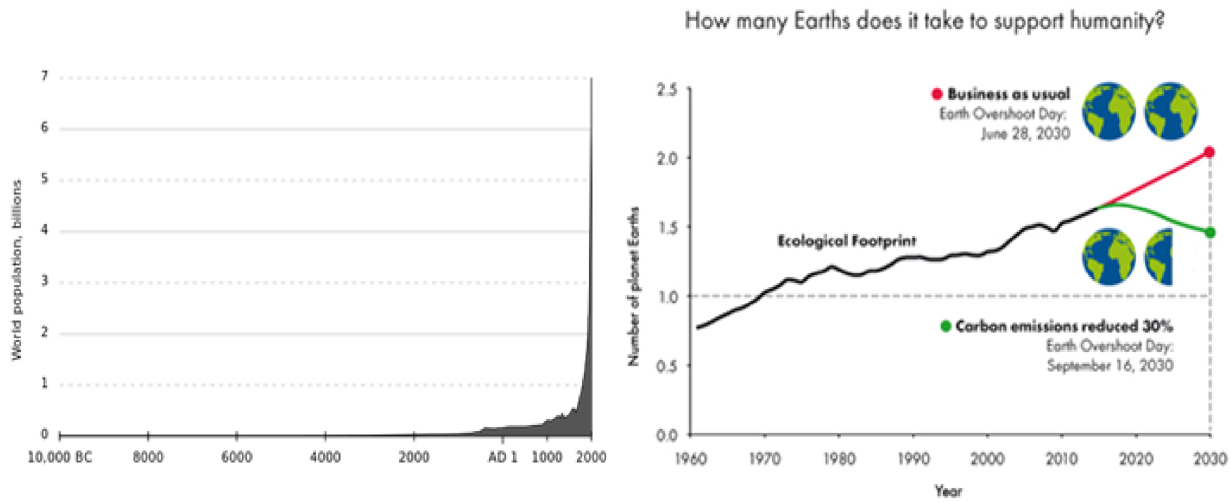


FIGURE 7 Growth and consumption (two graphs that say more than a thousand words…) On the left side we see human population growth (in billions) from 10 000 BC to 2 000 AD (Public domain), and on the right side we see the development in world ecological footprint (i.e., consumption of natural resources) since 1960 (Credit: Global Footprint Network) – both clearly stating that we are a species in "overshoot."

7. Eyes of Evolution

So then, how do you propose that the world really works? And what are these so-called 'unconscious' forces driving our collective behavior?

Well, I don't think anyone can tell you that for certain. There are just too many unknowns, and there probably always will be. And even if we did, we might still remain unsatisfied. What I do believe, however, is that to find potential answers to such imposing questions pointing towards our true nature, we must venture – on a road less travelled – into the deep, dark, and murkier "waters" of humanity. We must dare to ask ourselves questions of not only a philosophical but also of an existential nature: "Who are we?" "Where are we from?" "And what is our purpose?" And when searching for answers we must, however unpleasant, remove the soft layers of our cozy and protective "clothing", and although "vulnerable" and cold, stand before the mirror, exposing ourselves to the naked truth of our not necessarily so special "selves": bodies of imperfections, of scars, of life, and…of "history."

And that "history", in my view, is best seen in a broad cosmic context, through the eyes of evolution.

Part III: Captivating Concepts

In order to analyze human behavior in an evolutionary context, I have come to the conclusion that it is necessary to know the key properties of the following three concepts: Biological Evolution, Complexity Theory, and Thermodynamics.

This means, of course, that we need to dedicate some time to theory. And that is precisely the purpose of this segment – a review of the three concepts first principles. Enjoy!

8. Biological Evolution

Evolution, broadly understood, is simply a gradual process where "something" changes its properties – a development of some kind – into a different (and sometimes more complex) form. Biology, on the other hand, is the study of living organisms. As such, when merged, one should interpret Biological Evolution *as changes in the properties, or the genetic constituents (see Fact Box 1), of an organism's population during successive generations.* And this is exactly the definition found in the dictionary [21]. Consequently, evolutionary processes, biological or otherwise, are never in a constant state; they are always changing, always moving about. Albeit, as to how the change unfolds can either be slow and steady manifesting over eons, or occur very rapidly as such is the case of the single celled organism, foraminifera [22].

> ”PHILOSPHICAL FOOTNOTE”:
>
> Keep in mind, however, that how one defines "gradual" is actually a matter of perspective measured across different timescales. For instance, the gradual change in the properties of airplanes – from the Wright brothers primitive prototypes to the development of the modern jet fueled commercial airliners in less than a century – can, when measured in terms of a human lifetime, be considered relatively slow, but when compared to the gradual formation of galaxies in the universe, it is hyper fast – a fraction of a nanosecond.

FACT BOX 1: MOLECULAR MATERIAL

Primarily, the building blocks of an organism consists of the chemical mixture of complex carbohydrates, proteins, nucleic acids and lipids – also recognized as the four macromolecules crucial for all known forms of life [23]. Placed within the nucleic acids, we find the well-known molecule of DNA (Deoxyribonucleic acid).[16] DNA is an organic compound residing within the cell nucleus in eukaryotes (multi-cellular organisms) and in the cell nucleoid in prokaryotes (single celled organisms) where it is acting as a biological information storage room. Essentially, DNA's basic task lies in providing the "recipe" (or genetic instructions) for the growth, development, and reproduction of an organism. In addition, a regional part of the DNA codes for function, thereby acting as a molecular unit of heredity, in what we common folks refer to as a gene [24]. A gene, however, is susceptible to both mutations and other external environmental impacts (through epigenetics – the science of how genes are turned on and off [25]).

Darwin's Formidable Force

Within the framework of Biological Evolution there operates a powerful force, one accountable for all the variations of life, both current and in history. This is *Natural Selection* – a term popularized by the famous naturalist and geologist, Charles Darwin (1809 – 1882). In his seminal book *On the Origin of Species* in 1859, Darwin talked about natural selection as "one general law leading to the advancement of all organic beings – namely, multiply, vary, let the strongest live and the weakest die [26]." What Darwin basically conveyed was *that within every population some individuals are better able at surviving and reproducing than others.*

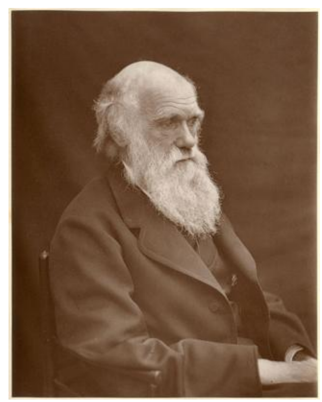


FIGURE 8 "Charles Darwin", Photograph by Leonard Darwin 1874 (Public domain)

[16] … and RNA (Ribonucleic Acid), which works as a "translator", where the sequence information within the DNA is translated into the "sequence of amino acids in proteins in the cytoplasm of all cells [115]." But we will leave RNA out for the sake of avoiding confusion.

Usually referred to as "survival of the fittest," Darwin's definition is a rather "egocentric" view of biological evolution. However, studies show that natural selection operates at other magnitudes as well. For instance, in the last decade or so, the powerful force of *group selection* (the theory that groups and communities compete among themselves for survival) is given more and more room in academia, and literally beginning to outcompete the selfish gene theory of neo-Darwinian thought [27]. Thus, in what is referred to as *multilevel selection*, the idea is that natural selection, just like Russian matryoshka dolls, operates at many levels at once.

FIGURE 9 Multilevel selection model by David Sloan Wilson and Elliot Sober illustrated by a nested set of matryoshka dolls [116]

Other Evolutionary Modes

Beside natural selection, there are other evolutionary forces just as important, "tugging" away at the molecular diversity and complexity of life – the most prominent ones being mutation, sexual selection and symbiosis. Let us then, before addressing the fascinating field of Complexity Theory, review these other "modes", beginning with…

Mutation

Mutations – *the change in an organism's DNA (the hereditary material)* – happens all the time, many of them without any evolutionary significance. In other words, although a single mutation *may* significantly affect an organism's morphology, since most of them don't, mutation, as a selective force, is thought to operate by accumulation, which is known as *Gradualism* within the field of evolutionary biology.

FIGURE 10 Mutation in Moss rose resulting in flowers of two colors [117]

The theory of Gradualism, which was the traditional all-encompassing way of understanding speciation (but as we shall see, this is not the case anymore), thinks of adaptive change as gradually happening through a species' history (i.e., that the molecular change happens at a steady state). This applies both to the species itself, as well as when lineages divide [28].

Sexual Selection

Sex, while making teenagers blush and giggle in embarrassment when insinuated, is simply – in biological terms – the mixing of genetic material. Sexual selection, however, is not about genetic shuffling per see (although that is usually the outcome), *but an organism's ability to successfully copulate with a mate* [29]. As for how different organisms copulate, there are as many ways as there are people's opinions. From the peacock's ornate tail display to the redback spider's masochistic suicide sex dive[17], the process of sexual selection is rife with competition, seduction and deceit, where different organisms goes to different lengths (sometimes even detrimental to an individual's health) in attracting or conquering the opposite sex, thus propagating their genes.

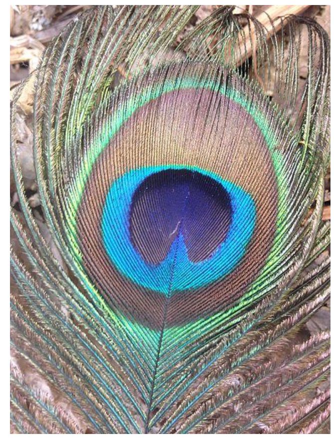


FIGURE 11 Peacock feather [118]

Symbiosis

Derived from the Greek words "living" and "together", in what bankers would describe as the Merger & Acquisitions department of natural selection, symbiosis is simply a technical term for the biological interaction between organisms – or more specific, *how* different organisms live together within their life cycle.

FIGURE 12 Symbiosis between Common Clownfish and the Magnificent Sea Anemone [119]

As nature is freed from the barriers of political bureaucracy, it has formed a myriad of symbiotic relationships. Here we find parasites – organisms feeding off each other; we find partnerships so entangled that one organism cannot live without the other (lichens

[17] Talk about fatal attraction: the male literally hurls itself into the female's jaws of death potentially being devoured [120].

is such an example); known as endosymbiosis, we even find organisms that are "breaking and entering", claiming permanent residence in another organisms cell (e.g., Mitochondria and chloroplasts) .

From such examples, within an otherwise so individualized "survival of the fittest" framework of Darwinian natural selection, we see that there is a huge element of cooperation. "Life", according to the late biologist/scientific rebel Lynn Margulis (1938 – 2011) and her son, the acclaimed science writer and theorist Dorion Sagan, "did not take over the globe by combat, but by networking [30]." They point to the fact that symbiosis, by the theory of *Symbiogenesis* – which the aforementioned Margulis actually is the terms "originator" – works as an evolutionary force in the creation of new species.

Symbiosis, in other words, rather than being in line with the traditional view of Gradualism, is consistent with the theory of *Punctuated Equilibrium* where – as stated by its originators, the paleontologists Niels Eldredge and Stephen Jay Gould (1941 – 2002) – "the history of evolution is not one of stately unfolding, but a story of homeostatic equilibria, disturbed only 'rarely' (i.e. rather often in the fullness of time) by rapid and episodic events of speciation [31]."

9. Complexity Theory

Built on the theoretical ideas of disciplines such as general systems theory, computer science, chaos theory, information theory, and evolutionary biology amongst others, Complexity Theory is a branch of science *dealing with complex phenomenon not necessarily explainable by the traditional theory of reductionism.* As such, by a set of concepts, the science's main purpose lies in investigating different systems (both natural as well as artificial) without reducing a system to its parts, acknowledging instead that systems are networks – a multitude of relations between components – where structure, dynamics, adaptability, and unpredictable emergent properties are present [32].

Although complexity – like the ambiguous description of the "state" of happiness – is extremely difficult to define as well as context-dependent, we somehow intuitively know it when we see it. For instance, in comparing the operating mechanics of a lever or a pulley with, let's say, cell metabolism, most of us are able, quite easily, to differentiate between the levels of complexity: one fairly simple, the other dauntingly complex. There is, however, usually more to life that "meets the eye" than a simplified and somewhat "caricatured" example as this. It just ain't that easy when dealing with complexity – particularly when considering how Don Mikulecky, an American physiologist, defines it as "the property of a real world system that is manifest in the *inability of any one formalism* (emphasis mine) being adequate to capture all its properties [33]." If correctly interpreted, Mikulecky basically states that there is no "holy grail" so to speak in understanding complexity, and, ironically enough, this is exactly the reason why "something" (in this case systems) should be classified as complex. In other words, understanding complexity is, well, "complex"…

Complex Systems

We have somewhat touched upon it already: when talking about complexity it feels natural to talk about systems. Like peanut butter and jelly, or milk and cookies for that matter, complexity and systems are to some extent complimentary – one goes surprisingly well with the other. Just look at the definition of *system* – "a set of interacting or interdependent component parts forming a complex/intricate whole [34]" – and you see what I mean. No wonder they are so intertwined.

Properties

So what is it that makes a system complex? Or said otherwise: what is the difference between any system and a system categorized as complex? Well, according to complexity scientists, for any system to be defined as a complex system it must – if not all – at least exhibit some of the following characteristics of: 1) structural hierarchies (arrangement), 2) spontaneous order (self-organization), 3) apparent signs of stability or robustness, 4) feedback loops; meaning every element is both "cause" and "effect", and 5) emergent behavior that cannot be deduced form the individual behavior of its constituents (also known as non-linear dynamics) [35].

Limits

As for limits, there are several, three of which are critical [36]:

Firstly, as complex systems are (as we now know) composed of a multitude of constituent parts, they are of course prone to component failures. Keep in mind however, as described above, that complex systems are known to be (or at least appear to be) resilient and to some extent "robust" (and in the case of a CAS [see page 32] dynamic as well), indicating that the failure of one component, or several for that matter, may not be perilous to the system as a whole intrinsically. Nevertheless, in nature, when dealing with components (especially when a large quantity of them are connected) there is always the possibility of the proverbial "straw that broke the camel's back": the potential that even the smallest failure can be followed by an unforeseen and uncontrollable event, as in cascades, resulting in a systemic failure and, at worst, possible collapse.

Secondly, as all systems – complex or not – rely on their external environment for inputs (energy and resources) and outputs (products and wastes), the failure in any "entity" or "entities" providing such "services" may case disruption amongst its recipients. That is, even if the internal components of the system are, for the lack of a better word, "intact", it is still vulnerable to external influences, and as such, by any means, at the mercy of its surrounding environment.

Thirdly, virtually all complex systems are susceptible to the forces of aging. Now, it is important to clarify that when speaking of aging we are not necessarily referring to the final state of death (although that is more often than not the outcome), but as in the actual process of aging – called *senescence*, which is derived from the Latin word *senescere*, meaning "to grow old [37]." All systems have natural life spans – animate and inanimate alike – where they appear (emerge), grow, learn, establish habits, and become inflexible (as in too rigid[18]), followed by dissolution – as in breaking apart.

[18] For example, try changing your grandfather's political views…good luck with that!

Types

As if that wasn't difficult enough already, complex systems are also divided into different types as well. Now, before we continue I want to pause for a moment and give a slight caution to the reader as this might complicate matters further. Nevertheless, in order to fully understand the properties of complex systems (i.e., to have sufficient knowledge of how complex systems "works"), there are two types that we need to attend to: namely chaotic systems and complex adaptive systems.

Chaotic Systems

Whether it is traffic, children's birthday parties, or "crazy days" (ala black Friday) at shopping malls, when talking of chaos people usually refer to an unorganized mess of some sorts. And they are rightfully so, as per the dictionary chaos is defined as "a state of complete confusion and disorder [38]." Within the field of complexity theory, however, there is talk of deterministic chaos, or D chaos as it is sometimes referred to. Now, the astute reader would be quick to point out that this sounds like an oxymoron and wonder, rhetorically "How can pure randomness be deterministic? It can't can it?" Well, somehow it can. And the answer lies strangely enough somewhere between mathematical modeling, weather phenomena, and the flap of a butterfly's wings.

With the onset of the computer in the 60's came not only the facility to iterate mathematical equations like never before, but also the ability of turning the subsequent results into visual correlations. As chance would have it, a new platform for system analysis was born.

In his research of weather prediction while utilizing these modeling "powers" brought forth by the computer, Edward Lorenz uncovered something profound: If rerunning a weather model in the middle instead of at the beginning, the MIT mathematician/meteorologist – probably to his amazement – saw that the end-results diverged immensely. This could only indicate one thing: that a complex system's behavior, although derived from a simple but nonlinear rule (hence the word deterministic), shows extreme sensitivity to slight differences in its initial condition. And this was exactly the cause of Lorenz startling revelation – infinitesimal rounding errors produced by his computer[19]. As it often is with history, in a chain of events where one thing leads to another, this groundbreaking discovery led to the formation of Chaos Theory and the famed "butterfly effect" – derived from Lorenz's 1972 article "Does the Flap of a Butterfly's Wings in Brazil Set Off a Tornado in Texas? [39]"

Subsequently, it became abundantly clear that predicting the future behavior of a complex (chaotic) system is impossible. To do so one would need to know the system's entire initial condition down to an infinite level of accuracy. Yet somehow, despite all the disorder, such systems, paradoxically enough, still display some organization; often through fractals (repeatable but non-identical patterns), the infamous weather being such an example.

FIGURE 13 Two examples of fractals in nature where we see patterns which are repeatable but non-identical. LEFT: Hurricane (Credit: NASA, Public domain), RIGHT: Fern [121]

Complex Adaptive Systems

We have all heard them: expressions such as "learning by doing", "learn from your mistakes", "learn to live", and "live to learn." Inferred in such adages I would presume (although it could be unintentional) is the reference to "adaptability" as in being "able to change or be changed in order to fit or work better in some situation or for some purpose [40]." The same somewhat applies to a special "breed" of complex systems as well – namely Complex Adaptive Systems, or CASs.

[19] Lorentz computer rounded off at six digits.

By itself a Complex Adaptive System (CAS) is not only complex, i.e. consisting of multiple interrelated parts (within a CAS referred to as agents), but also dynamic with the capacity of learning from experience. Hence the description as adaptive: possessing the ability to change and evolve with (and to some extent influence) its surrounding environment. As such, there is no separation between a CAS and its surroundings; they are both interconnected, "feeding off" each other, changing its characteristics. In other words, contrary to the "predetermined" behavior of mechanical systems – such as an engine, a chainsaw, or an automated assembly plant – the aggregated behavior of a CAS's agents operates dynamically by responding to the feedback it receives from its environment, adapting to new conditions in a non-deterministic way [41]. It shouldn't then come as a surprise that the behavioral properties of a CAS cannot, as it applies to all complex systems (adaptable or not), be predicted from neither the actions of its aggregated agents nor by dissecting its constituent parts. In that respect, "the whole" as the great Aristotle said "is greater than the sum of its parts [42]."

10. Thermodynamics

"It is the only physical theory of universal content, which I am convinced, that within the framework of applicability of its basic concepts will never be overthrown [43]." You know that raggedy mustache and frizzy haired guy, that eccentric little gentleman just a tad famous for his theory of relativity? That's him, Albert Einstein, talking about thermodynamics – *the science of energy states and flows* – identifying it as an area within physics least likely to change in the future. Einstein sure knew his physics, so such claim would not come unsubstantiated. In fact, it is not so at all, bearing in mind that the processes of thermodynamics – i.e., the transformation of energy and the movement of heat – are not only observable in nature but repeatable in experiments as well and, as such, proved to be governed by laws, making them fundamental to physics.

Before venturing into the realms of heat and energy (or more specifically, the laws of thermodynamics) I must first point out that – as this thesis neither provides the space nor the platform for such an extensive inquiry – we are not going to spend much time digging into the details of every law, hence the brief overview in Fact Box 2.

FACT BOX 2: THE LAWS OF THERMODYNAMICS

The Zeroth Law[20]

"If two bodies are each in thermal equilibrium (i.e. having the same temperature) with some third body, then they are also in equilibrium with each other [44]." As such, the concept of temperature is firmly established as not only fundamental but also a measurable property of matter.

The First Law

The conservation of energy; it states that energy (mechanical, chemical, kinetic etc.) cannot be created nor destroyed, only transformed. That is, although becoming less available for work energy will not diminish in quantity.

The Second Law

Sometimes referred to as the entropy law (derived from the Greek word *tropos*, meaning "transformation") it essentially states that a) the quality of energy diminishes with time, and b) that energy, unhindered, tends to spread. (Surprisingly simple, the basic equation for the second law is just heat transferred/absolute temperature = entropy).

The Third Law

"The entropy (i.e. the transformation of energy) of a system approaches a constant value as the temperature approaches absolute zero [45]." For example, as water cools – let's say from vapor to liquid water – some mobility is lost (the molecules can still move around, but not as freely) thus its overall entropy is reduced. This means that at absolute zero (as in 0 Kelvin, or -273 degrees Celsius) the entropy of the system is zero.

---

[20] Due to the fact that it wasn't properly inaugurated (i.e. named and numbered) until after the first and the second law was already firmly grounded within the sciences, it was named as such because there was no desire to change the initial numberings as it would only create confusion.

There are, however, facets (or perhaps more appropriately, aspects) outside the traditional field of thermodynamics that needs further investigation, one of which is a major source of confusion, the other found within the more exotic domain.

Entropy: A Silent Revolution

In recent years (in the last decade or so), within the sciences of thermodynamics, a silent revolution of rudimentary change is brought forth one chemistry textbook at a time. And it's all because of Professor Emeritus Frank L. Lambert, a stubborn yet clearheaded chemist with one goal in mind: to simplify an otherwise "obscured" view of the second law – the mathematically "mystified" view of *entropy* as a statistical measure, a ratio, of "disorder" (and thus any kind of disorder be it messy kitchens, car wrecks, or devastated war zones as entropy) [46].

Why this became the predominant view in the 20th century goes all the way back to a single statement produced by one of the founders of modern thermodynamics – the Austrian physicist part philosopher, Ludwig Boltzmann (1844 – 1906). In a four hundred pages long document drenched in complex mathematics Boltzmann concluded, in plain language, that since most of the universe around us appears (initially) to be in a state of order it is therefore very improbable, thus when left to itself it "rapidly proceeds to the disordered most probable state [47]."

And just like that, by chance, entropic confusion was thereof born; spreading like wildfire, clouding the sciences in a smoke of geek speak and "buzzwords", laying waste to the fact that entropy in all its *simplicity* is just the conversion of energy. "Energy of all types changes from being localized to becoming dispersed or spread out, if the process is not hindered [48]" – these are Lambert's words, his modern formulation of entropy, simple and elegant yet still catching the energetic essence of the second law of thermodynamics: dispersion.

So from now on, when I refer to the term *entropy* (e.g. entropy production, entropic waste or similar), it will be used in relation to energy dispersion, not disorder. If otherwise, I will of course alert you.

Nonequilibrium Thermodynamics

A daunting definition, isn't it? "Nonequilibrium thermodynamics." It's even hard to pronounce correctly – at least I think so. Fortunately, though inhabiting such an imposing name, it is somewhat easier to understand than one at first might imagine. Nonequilibrium thermodynamics, or NET (its scholarly abbreviation), you see, is just a technical jargon for open system thermodynamics, and evidently so because – and here I will let the experts do the talking, the ecological thermodynamicist Eric D. Schneider and his co-author, Dorion Sagan – "the system of interest, centers of flow, growth, and change, are not static, still or dead; they are not in equilibrium [49]."

And it's precisely this "openness" to flows that keeps such systems away from equilibrium. Because NET systems, unlike isolated or closed systems[21], are open to the flux of *both* energy and matter (see Figure 14), they maintain "order" and structure by the continuous dissipation of energy, inhabiting a sort of meta-stable state moved away from equilibrium. (Two prime examples being Bénard cells and BZ reactions, which are presented in Fact Box 3).

However – and this is important! Despite the systems locally reduced entropy (hence its' ordered state), the overall entropy production actually increases as energy flows through the system, being dissipated, according to the mandate given by the second law of thermodynamics.

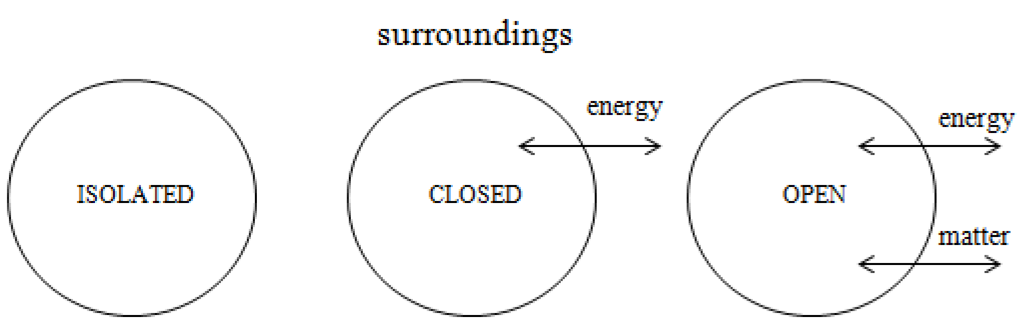


FIGURE 14 Differences in characteristics between an isolated, closed, and open system. Isolated systems neither exchange energy nor matter, closed systems permit energy but not mass, and open systems exchanges both. (Credit: Christian Wik)

[21] The former is enclosed by walls thus restricting transfer of neither mass nor energy; the latter permits energy but not mass.

FACT BOX 3: CONVECTION CELLS AND CHEMICAL REACTIONS

Bénard Cells

In their pristine state, most liquids are boring, lifeless and disorganized. But in a pot, heated from below, something exceptional happens: at a critical threshold, spontaneously, with no magic involved (other than heat and energy), out of the liquid "chaos" emerges a uniform cell-like structure of hexagonal shape. To those studying thermal convection, this is the well-known "honeycomb" structure of Bénard cells[22] – a simple yet striking example of a nonequilibrium thermodynamic system and a "self-organized" gradient reducer if ever there was one. And it's all because of a system facing temperature differentials, "resisting" the process of being "pushed" away from its natural state of equilibrium – hence the spontaneous formation of organization to more effectively reduce the gradient, break it down and dissipate its energy. As Figure 15 shows, the more organized the system, the better it is at producing entropy.

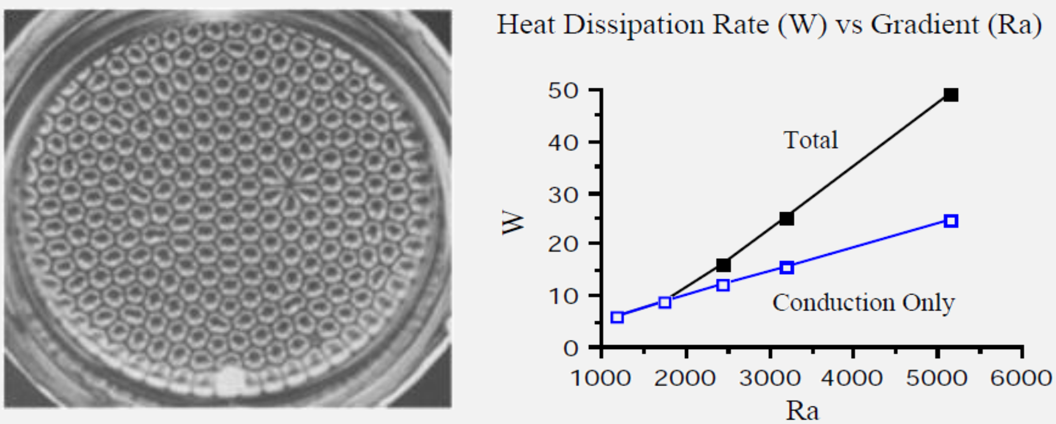


FIGURE 15: Heat dissipation rate in Bénard cells graphed showing that as the fluid goes from conduction to convection (i.e., at the threshold where Bénard cells are formed) energy is more effectively dissipated as heat (Source: Schneider & Kay, 1992 [122])

[22] They are named after Henry Claude Bénard (1874 – 1939), a French physicist best known for his research in convection in fluids. Because of their experimental accessibility – all you need is fluid (any kind of cooking oil would suffice), a pot or saucepan, a heat source (a stove or similar) and you're good to go – they are carefully examined and well documented. In fact, such study of "fluid in motion" traces all the way back to the late 19th century, or more specific in 1897, when polygonal flows ala Bénard cells, first were observed in an unused photographic developing tray [123].

Beloüsov-Zhabotinsky Reaction

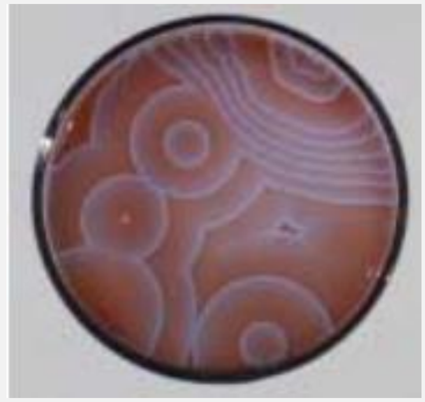


FIGURE 16 Chemical spiral waves of the BZ reaction [124]

The "chemical clocks" of the Belousov-Zhabotinsky (BZ) reaction is another such ""dissipative structure."[23] Although this time it is not heat that fuels the system, but chemical energy. Composed of a few relatively simple chemical compounds, when mixed, the BZ "brew" converts into chemical energy – a form of electromagnetic energy which, as it is released from its chemical bonds, powers "self-organization" while, simultaneously, dissipate as heat. In a clocklike manner, seemingly "alive"[24], the reaction switches between colors (oxidation states), and precisely so, as it proceeds towards chemical equilibrium. If unstirred, however, a different visual pattern forms: a pattern of concentric circles and spirals, a slow motion nonlinear oscillator, highly reminiscent of some overprized psychedelic artwork from the '60s.

11. A Brief Recap

Phew! That was quite an extensive review, I fully agree with you on that. Although I don't believe I could have made it any shorter either without sacrificing very important aspects of these, in my opinion, captivating concepts. As for remembering all of this, I neither expect you to nor is it a prerequisite for moving forward with this thesis. With that said, if not out of necessity I do feel it somewhat appropriately that I provide you with a brief recap of what I hold as the crux of the "conceptual matter."

[23] A term coined by the much acclaimed Russian-Belgian physical chemist, Ilya Prigogine.

[24] Apropos being "alive": Schneider and Sagan tells a funny story of when Professor Bill Early, as he was carrying a BZ reaction after a lecture, met two Jesuit priest in the elevator, whereby the priests observed the reaction's striking color change. "'Are those alive?' one priest wanted to know. There was a pause as Early reflected. 'They are like you, Father,' he said after a moment. 'They metabolize but do not reproduce [125].'"

So if nothing else, at least remember the following key takeaways: (1) that Biological Evolution are changes in the genetic constituents of an organism's population during successive generations, and that there are several "selective" forces – such as natural selection, sexual selection, mutation and symbiosis – operating within this framework, (2) that Complexity Theory is the study of phenomenon – as in any system – that are not necessarily explainable by reducing it to its constituent parts (such as emergent behavior) and that such systems can be both chaotic and adaptive, and (3) that within Thermodynamics – the science of energy states and flows – although consisting of laws considered fundamental to physics, we should pay special attention to the fact that the second law is not related to disorder but to the conversion of energy, and that the flow of energy itself may lead to a system forming, spontaneously, into a state of organization, more effectively at dissipating energy.

Part IV: Of Life and History

We see the moon as it was 1.3 seconds ago, we see the sun as it was 8.3 minutes ago, and we see the shining stars as they were millions, if not billions of years ago. We don't think much about it, but when we gaze into the cosmic scenery at night, we are always looking at events now belonging to history. And it's toward that history we now must turn to. This is where it all comes together. This is where we analyze and synthesize. This is where we dare to confront ourselves, our nature, and our behavior – even our "place" – within the greater context of life. This is where we must see ourselves in the mirror image, only this time with the eyes of evolution staring back.

Alien Anthropologist

Before we proceed, I want you to stop for a moment and do something with me – something of an imaginary nature, a mental "exercise" of some sort. Now, I expect you to find this either slightly silly or mildly embarrassing – or if you are like me, where the life as a responsible adult has chiseled away any childish curiosity for the fictitious, somewhat difficult. You might even find it completely unnecessary. That's ok, too. But don't you worry; the bar isn't set very high for this exercise. It's just to get in the right "frame of mind" so to speak, for the upcoming analysis.

So, what I want you to do is this: To the best of your ability, try and imagine that you are no longer "you", but instead a foreign creature visiting earth in a spaceship from another world, another time and, quite possibly, another dimension. In whatever shape or form – as that's for you to decide – your newly acquired "inner alien" has but one goal in mind: to study the human race, the genus *homo,* and its history, on the same terms as if it was any other kind of organism living on this planet, Earth.

Now, with your alien anthropologist "onboard" – and as it always is when a foreign entity occupies the mind – your inner voice changes its form. From now on, when speaking of humanity, there is no more "we" or "us", only "they." Remember, your current state of mind shares no ancestry with the species Homo sapiens, other than being a product of the cosmos. This might seem strange at first, I agree – somewhat colder and a bit more "clinical", perhaps. But do not despair for that reason alone as there is in fact a major positive side-effect to such a "third party perspective." It just so happens that the more distant the observer the better. It's easier to remain objective that way. Your thoughts and beliefs are far less in danger of being corrupted.

With that said… as for where to begin, your inner alien has for sure done "its" homework. And it resides in the past, deeply buried in Earth's history. It is without a shadow of a doubt that humanity is living in the footsteps of shadows from the past.

12. Shadows from the Past

To understand any species, its present form, and why it behaves as it does, we must begin by knowing where it came from: we must know its history – its evolutionary heritage. For our example of interest, the species Homo sapiens, it means a journey on a timescale so vast and deep that even *time* itself turns "abstract." And abstract, indeed – especially with lives lived in decades, a century at most – as we are not talking about a few millennia or so, but of geological time, stretching in the millions. So, in the realm of eons, this is where we begin: a quick tour of evolution on Earth – this blue marble, their home.

FIGURE 17 Earth seen from the Moon taken by Apollo 8 crewmember Bill Anders on December 24, 1968 (Public domain)

Earth History Timeline

On the vast cosmic arena, 4 600 million years ago, something marvelous yet ordinary[25] happened: the formation of the Solar System – the Earth, the Sun and the other planets surrounding it. Although little resembled the Earth as we see it today. Instead, the Hadean eon (which is named after Hades, the Greek god of the underworld) was a most violent period of terrestrial bombardment, molten rock, superheated gases, never ending lightning strikes, a boiling crust, and no oxygen [50] – a hellish time, indeed. Yet eventually, after 600 million years or so, the diabolical chaos of the Hadean eon "cooled" down, and the Earth transitioned into another eon, the Archean. Going back 4 000 million years, this is where the Earth's crust began its formation, and, by some scientists, believed to be the starting point of tectonic activity [51]. But it didn't end there, because this eon also marked the beginning of two remarkable phenomenon – or "revolutions", as some describe them to be [52] – of planetary change: the emergence of life and photosynthesis.

About 3 900 million years ago, this is the time it is believed that planetary metabolism took the first steps on its far-reaching journey. As for how it originated that is still not known, although several theories are to be considered [53]. We do, however, know that life began as "single-celled" – in the form of anaerobic prokaryotes, today known as bacteria. Such sulphur-metabolizing microbes have in fact been found fossilized in the 3 400 million-years-old rocks of Western Australia [54]. Now, with time these bacterial life forms "diversified", evolving several "modes" of metabolism, one being photosynthesis – which came into play by blue-green algae, the cyanobacteria, mastering the trick of "splitting water" (i.e. using hydrogen as an electron donor, releasing oxygen as a waste product). And just like that, by the miracle of microbial ingenuity, came the birth of atmospheric oxygen, leading us into another eon – the Proterozoic, 2 500 million years ago.

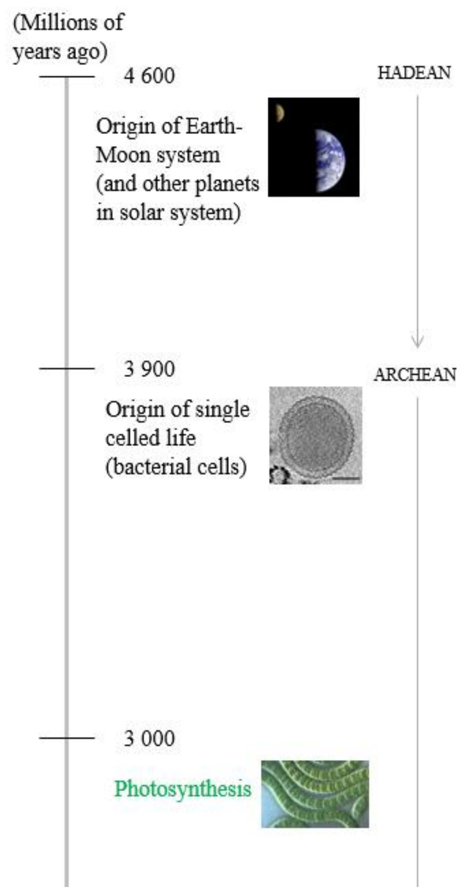
Although slow at first, the Proterozoic was far from an uneventful period on Earth. In fact, it was quite the opposite as this eon brought with it a pollution crisis of epic proportions so destructive that some refer to it as "the oxygen holocaust [55]." According to scientists, what happened was

[25] From a cosmic perspective the formation of a solar system is nothing exceptional, as it happens quite often to say the least.

this: You know those photosynthetic blue-green algae we talked about earlier – the cyanobacteria? Well, it so happened that they kept multiplying exponentially by utilizing every inch of readily available water to feed their newly acquired metabolism, dumping oxygen as waste – to anaerobic life, a lethal poison. With time, as natural sinks eventually got saturated (remember, these microbial "rascals" kept releasing ever increasing amounts of oxygen for 1 500 million years! or so), oxygen began leaking into the atmosphere violently shifting its balance[26], which then caused the death of almost every existing anaerobic life-form, in one of the worst extinction events ever to take place in Earth's history [56, 57].

Now for life's diversity, this could have easily marked its end. Yet it didn't. Instead, death was followed by opportunity; what was once lethal now became beneficial. By turning the once so poisonous oxygen molecule into chemical energy, life roared back – and it did so more diverse than ever.

FIGURE 18 A timeline portrait of Earth's history (Credit: Christian Wik)



We are now in the Phanerozoic eon 600 million years ago, and life continues its "territorial" expansion. A third kingdom[27] appears: Animals – first as chordates; then reptiles and mammals (plus a myriad of other organisms). In fact, in 40 million years or so – which on a geological time scale is equivalent to a mere fraction of a percent, it's that fast – we saw not only the rise of the lineages of most of the animals existing today [58] but also that life began incorporating an increasing amount of elements into its metabolism [59]. However, such an expansionary phase did not go on without setbacks; "destruction" would yet again rear its ugly head.

Five mass extinctions[28] and a positive hydrocarbon balance later [60], we reach the Cenozoic eon, 65 million years ago. Here,

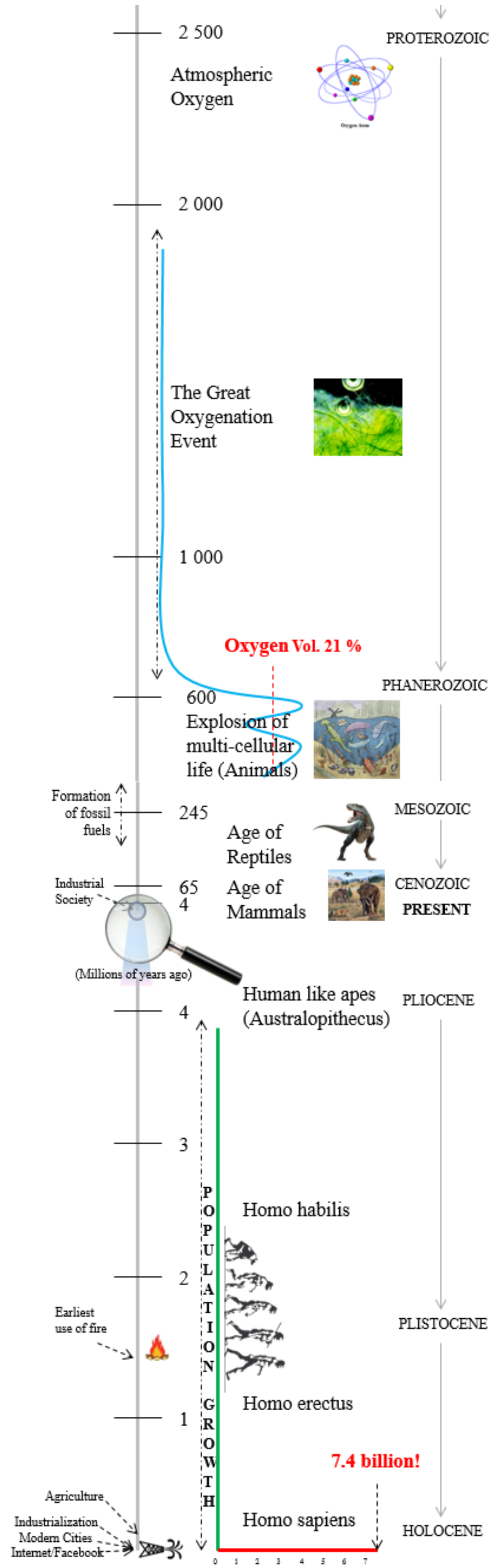
[26] Oxygen increased from less than zero to an astonishing 21 percent (!), where it still remains as of today.
[27] The two other being bacteria and protoctists.
[28] In the previous 500 million years or so – in the Phanerozoic, the Mesozoic, and the Cenozoic eon – life's participants had to endure the events of mass extinction in the following periods: The Ordovician-Silurian, 444 million years ago; the late Devonian, 375 million years ago; the Permian-Triassic, 251 million years ago; the Triassic-Jurassic, 200 million years ago; and the Cretaceous-Tertiary, 66 million years ago.

after the death of the dinosaurs, animal life had yet again emerged from the preceding carnage. Although this time the dominance (at least visually) was not of cold-blooded reptilian heritage, but of warm-blooded mammalian decent [61].

With the dinosaurs gone, and thus with diminishing prospects of being eaten, mammals flourished – and once again, on a geological timescale, they did so astonishingly fast. In just 60 million years or so mammalian life would come to occupy every ecological "niche" as it evolved from small rodent-like life forms (as these were the only ones that survived the K-T extinction) to such massive "beasts" as mammoths, orcas, and saber-tooth tigers; and later elephants, bears, dogs, and marsupials, as well as a plethora of others – the so called megafauna [62].

And then, at the very end of the Cenozoic eon, on the east African plains, there it was: the first human like ape, a primate – the Australopithecus. We have here on our hands *the ape* that would become the precursor to the species *Homo* – first as Homo habilis, then Homo erectus, and, finally, about 200 000 years from the present, as Homo sapiens. Thus in 4 million years or so, the Australophits, vegans as they were, had speciated to become meat eating Hominids – of which one, the species Homo sapiens, would rise to become one the Earth's most formidable predators.

However, the ascent of the "sapiens" was far from an easy one. Physically, as this species (just as the other hominids) was neither gifted with sharp claws or fighting teeth nor was it particularly strong or swift in its movement, it was far inferior to its contemporary predators in the Pleistocene. Yet, such



physical deficiencies were offset by two genetically disposed assets which proved to be of remarkable value: opposable thumbs and a growing brain. Instead of succumbing as an easy prey, these clever apes "fought back" through brain-powered social cohesion and cooperation by becoming tribal. As they soon would learn: there was strength in numbers, indeed. And with time, as their tribal bonds grew tighter, so, too, did the complexity of their language – which, when "coupled", became a powerful cocktail of adaptive change as it translated into complex hunting strategies, more effective weapons, and usable tools [63]. The once so physically inferior had suddenly become strategically superior at hunting big game. And whilst Homo sapiens claimed the upper hand of natural selection relative to the other terrestrial species in its time, they did so never looking back. As they migrated from dangerous plains of east Africa into the "new world", their presence would eventually (and exponentially) manifest itself on every continent, in every corner, and in every place – on the countryside, in cities and, even, in outer space.

FIGURE 19 In ~200 000 years, less than 0.00005 percent of Earth's history, Homo sapiens emerged from small banded tribal groups to take residence in metropolitan cities with millions of inhabitants in densely populated areas. LEFT: Indigenous encampment (Public domain), RIGHT: City of Guangzhou, China [126]

From Chimps, CHNOPS and Beyond

Although not explicitly stated, what should be deduced from the segment above is that human beings are "products" of an evolutionary past – a 4 000 million years old metabolic journey – as are all living beings on Earth – from bacteria, butterflies, and birds, to pop stars, popes and corrupt politicians.

Even so, this is not necessarily a “view” shared by humans themselves. In fact, according to Gallup’s[29] latest values and beliefs survey conducted in 2014, more than 4 out of 10 Americans continue to believe that God created humans in their present form as little as 10 000 years ago – a belief that has pretty much stayed the same since the poll first was conducted in 1982 [64].

Now, you could argue that this really doesn’t sound too bad as surely then the other 60 % must believe in evolution, right? Well, one could reasonably think so, but no. If you dig into the numbers you’ll discover that 3 out of 10 Americans, although they do think that humans evolved over millions of years, still believe that God was the one guiding this process. In total then, what we have here is the fascinating fact that in America at least – even though they live in a society where scientific facts are highly accessible – the majority of the public does not think of themselves as products of an evolutionary past, and that alone.

Which brings us to this segments’ purpose: to once and for all drive home the point that human beings are part of an historical continuum and, as such, no different from any other species, organism or life-form claiming “residence” on Earth.

To do so, I will present you with three scientific facts that places humans firmly within the historical context of life on Earth, even “at one” with the Universe.

Let’s begin with…

Fact #1 – Human beings are risen apes, not fallen angels

What scientists discovered as they compared the genome of the great apes by the rigorous process of DNA sequencing [65] was the startling fact that humans share an astonishingly 99 percent of their DNA with chimps and bonobos, even gorillas (at 98 percent) [66]. For humans this became a most humbling proof that human beings are not descendants of gods, but apes – and that their ancestral lineage, like all other primates, is of mammalian heritage. This is why various aspects of human behavior – from kindness to cruelty, from violence, sex, and political

[29] Gallup is an American research firm highly known for its public opinion polls.

power to altruism and morality – although in varying degrees[30], are found within the social constructs of both chimps and bonobos [67] as they are indeed genetically proven to be mankind's cousins.

But that humans are apes is not all that scientists discovered while they "chipped" away at different genomes. They also unveiled the fact that humans share DNA with a myriad of other species and organisms – most likely all known terrestrial life forms – whether it is cats, dogs, cows, rats, mice, chickens, or fruit flies, even non-living bananas [68, 69, 70, 71]. In fact, by linking cosmology with biology – by breaking down the light from stars, and by gas chromatography of tissue samples – scientist discovered something profound, that…

Fact #2 – Human beings are made of the same "stuff" as all other life forms on Earth

Take a good look at the table below. Here we see the chemical composition of human beings relative to three other organisms – the alfalfa, copepod and bacteria.

Element	Homo Sapiens	Alfalafa	Copepod	Bacteria
C	19,4	11,3	6,1	12,1
H	9,3	8,7	10,2	9,9
N	5,1	0,8	1,5	3,0
O	62,8	77,9	80,0	73,7
P	0,6	0,7	0,1	0,6
S	0,6	0,1	0,1	0,3
CHNOPS Total	**97,9**	**99,6**	**98,1**	**99,7**
Other	2,1	0,4	1,9	0,3

TABLE 1 Atomic composition of four different species of organisms (Adopted from Morowitz, 1979)

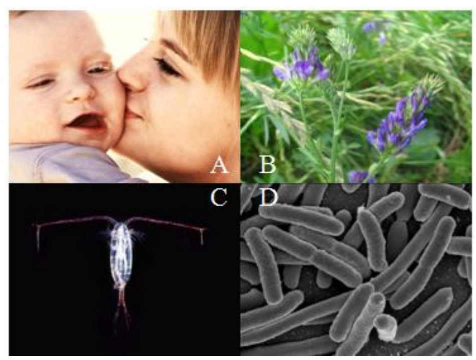


FIGURE 20 A) Homo Sapiens [127], B) Alfalfa [128], C) Copepod [129], D) Bacteria (Public domain)

Now keep in mind that these are four organisms belonging to different kingdoms, inhabit different cell organization (three being multi-cellular, one – the bacteria – being single-celled), and have different modes of reproduction, lest not forget the difference in form, figure and, of course, "looks." And yet, despite such differences, their atomic composition in percentage of

[30] Chimps live in hierarchical male centered groups fueled by power and dominance, while bonobos live in female centered groups with a high degree of sexuality which acts as a social lubricant.

bodyweight is nearly identical; they all consist of approximately the same basic elements of Carbon, Hydrogen, Nitrogen, Oxygen, and Phosphorous. Indeed, all life forms on Earth, whether it's bacteria, protoctists, fungi, plants or animals, are all made of CHNOPS – elements born in the interiors of collapsing stars [72].

This is why Carl Sagan (1934 – 1996), the famous astronomer and popularizer of science, wrote that humans are "made of star stuff" [73]; referring to the fact that life and its participants are of cosmic origin and no other, not only in "mind"[31] but also, as we have seen – quite literally – in body.

And as if that wasn't enough already, there's actually a third fact which connects humans with other species and life forms even further than just being mere mammals and molecular "star dust", that is…

Fact #3 – Human beings are "interspecies communities"

And how do we know this to be true? By looking at evidence from current biological research:

Just consider the following three findings; 1) that there is at least (at a minimum[32]) a 1:1 ratio between the number of bacterial cells to human cells [74]; 2) that the "energy factory" within human cells, the mitochondria, has its own DNA and thus believed to be of bacterial origin [75]; and 3) that essential vitamins – such as B12 and Vitamin K – are synthesized by the microbiota residing within in the gut of its human "host" [76]; and a picture of humans as "interspecies communities"[33] clearly emerges. According to biologist Clair Folsome, if every cell in the human body was utterly destroyed "what would remain", he vividly writes, "would be a ghostly image, the skin outlined by a shimmer of bacteria, fungi, round worms, pinworms and various other microbial inhabitants. The gut would appear as a densely packed tube of anaerobic and aerobic bacteria, yeasts, and other microorganisms. Could one look in more detail, viruses of hundreds of kinds would be apparent throughout all tissues. We are far from unique. Any animal or plant would prove to be a similar seething zoo of microbes [77]."

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[31] Humans, with their evolved consciousness, can in such regard be seen as if the Cosmos is looking at itself.

[32] Researchers are still debating the "magnitude" of the ratio of bacterial cells to human cells. Depending on "modes" of calculation some believe it to be a ratio of 100:1 while others at 10:1. Nevertheless, all agree on the importance of the microbiota.

[33] A term borrowed from Dorion Sagan's book "Cosmic Apprentice" [130]

This is exactly why human beings (and other species and organisms for that matter) are described as "Holobionts" [78] – biomolecular "networks" in symbiotic relationships with various microbes and organisms – rather than just as autonomous individuals. Now, ain't that something…

13. Simple Truth(s), Complex Reality

By now, I hope that my message is clear: Human beings, even though they may hold attributes of "uniqueness", are anything but special and thus susceptible to the same evolutionary forces as any other species or organism, and will, therefore, "behave" accordingly.

For instance, let's consider the human drive for status, say, through the means of political stature, fame, or (digital) fortune; or the devious game of courting, say, by attracting the opposite sex through excessive consumption (e.g., flashy cars, extravagant houses, fashionable clothes, or expensive vacations); or, say, the "lust" for copulation; or, say, the "desire" for myths and mystics; or, say, the emotions of love, affection, dedication, and devotion: these aren't traits of a god-given "agency", but of biology – these are innate traits that ultimately, in the face of selection, are geared towards growth and survival of the human "hive."

The simple truth is that humans are what biologists refer to as a K-strategist species [79]: one that will always be pressing up against its carrying capacity, expand into all available habitats, and always use up its accessible resources. Yet, when confronted with the possibility that humans "do so" (i.e., behave as a K-strategist) not *only* because of natural predispositions rooted in biology but *also* because they are open systems, far from equilibrium, is a "reality" far more complex.

"PHILOSPHICAL FOOTNOTE":

Humans is currently the most successful species on the planet at expanding its habitat; so successful that they even – through global supply chains and trade – occupy habitats that are, in principle, uninhabitable. Just think of Las Vegas and its 600 000 inhabitants located in the dry Mojave Desert. How do you think this city's inhabitants would fare if the possibility of importing resources was somehow removed?

In the Mirror of Metabolism

When the late American biophysicist, Harold J. Morowitz (1927 – 2016), wrote, in his seminal book *Energy Flow in Biology*, that "the flow of energy through a system acts to organize that system [80]", he was pointing towards the curious connection between energetic flows and biological organization.

By using simple systems modeling combined with mathematics, thermodynamic principles and statistical mechanics, Morowitz demonstrated two facets that, at least from a behavioral standpoint, can only be described as nothing short of "groundbreaking": Firstly, that living organisms, physically, are autopoietic systems far from equilibrium (i.e., nonequilibrium thermodynamic systems [NET]), and secondly, that this – considering the fact that there are NET systems beyond the "living" – connects life with non-life.

And what an extraordinary revelation this turned out to be, as what Morowitz shows, then, is that when a human being – be it a man, woman, or child – stands before a mirror what reflects back is not just an upright lump of multispecies "flesh", but an organized system of molecules and matter capable of regenerating and reproducing itself biochemically; that this being, this "mirrored entity", is in fact a complex metabolic system whose "goal", thermodynamically, is to stay in a stable state, away from equilibrium.

Although theoretically somewhat challenging (the mathematics applied is quite dense to say the least), it is surprisingly easy to establish that humans are nonequilibrium thermodynamic systems, practically. Just touch one's skin, and you will feel "warmth." Use a thermometer, and you will see that its thermal state – according to the zeroth law of thermodynamics – will change from whatever its initial temperature, smoothly, until it hovers around 37 Degrees Celsius (~ 98.6 Degrees Fahrenheit). This is heat: the dissipation of energy, energy that flows through the system keeping it organized.

So, in order to maintain a state of "meta-stability", humans (or any other organism for that matter) must seek towards energy gradients of which to "feed on", degrade, and exploit. If not, they risk the consequence of falling (and quite rapidly so, too) into the dreaded state of equilibrium – death. Indeed, all levels in the trophic pyramid – from primary producers to carnivores and everything in-between – seem to have this thermodynamic impetus for energy expenditure: Whether it is sun-devouring seaweeds, grass-nibbling rabbits, or meat-loving lions, they all, however they go about it, recognize their surrounding environment as potential energy gradients to be consumed so that they can remain "alive", away from the motionless state of equilibrium. No wonder humans have such an innate fear of "death" and such powerful feelings of hunger and thirst – feelings that, if pushed far enough, will drive even the sanest person to heinous acts that under normal circumstances are deemed "unthinkable." (Just consider what happened in the *Miracle of the Andes*, when, in 1972, a flight carrying a Uruguayan rugby team crashed in the treacherous terrain of the Andes, forcing the survivors, who soon ran empty on food and water – and with no rescue in sight – to feed, despite violently resenting doing so, on their dead fellow passengers as the only way of survival [81]. A classic example of metabolism first, "free-will" and "choice" thereafter…)

However, before delving further into the *raison d'êtres* behind such "purpose"-driven thermodynamic behavior, let's take one step back and revisit Morowitz claim that energetic flows through a system "acts to organize that system." It just so happens that this does not only apply at the human level, individually, but at all levels of "society."

A Question of Ancient Sunlight

You are stationed in one of the space stations orbiting the Earth. The year is 2017. And below, in the dark-blue curvature of the horizon, are the contours of the continental shelf of Europe as it rotates, gently, from the delightful daylight into the quiet hours of nightfall. You look down, and then, gradually, there appears a sight nothing short of breath taking: Out of nowhere, in the surrounding darkness, you see lights emerging everywhere. They are scattered on the surface in clusters – glowing, burning – yet strangely attached to one another. It is as if an untold number of mountainous volcanoes (some bigger than others) suddenly erupted at once, discharging rivers of hot, molten lava of which – by the gracious pull of gravity – can do nothing else but to flow downstream into the cold, dark valleys beneath them.

Spellbound by the sights' immensity, you pause and reflect:

Mesmerizing, isn't it? To think that such a glimmering inferno is neither magma writ large nor is it any other raging disaster, but instead the workings of human civilization.

FIGURE 21 The continent of Europe at night – London, Paris, Amsterdam
(Credit: NASA, Public domain)

Suddenly, and without warning, you find yourself orbiting the Earth, say, 250 years earlier – and please don't spend any time pondering about how this even became possible, only accept that it is. The year is 1767. And the continental shelf of Europe gently approaches, again. You look down, expecting to be greeted with another, for the lack of a better word, "enlightening experience", yet nothing happens – the surface remains pitch black. However, you are of the patient kind, so you wait some more. Time passes. Still, there is nothing – not even a speck of light to be seen. Finally, becoming tired and bored you succumb, eventually accepting the harsh reality that the continent you so desperately wanted to see has slipped beneath your feet without ever revealing its presence.

Described above, in the first paragraph, was an example of an emergent property. Because that is what all that "light" really is: a self-organized system displaying itself physically. Yet, it doesn't explain why the surface "lit up" in 2017, but remained in the dark 250 years earlier. That, however, is – as you will discover – more a question of ancient sunlight.

What it does illuminate, though, is that in order to get a complete picture of human behavior, we must reach beyond the mere individual. Why? Because not only does human civilization with its aggregate activities through a globalized economy reflect "realities" expressed through thermodynamics, but also the characteristics associated with complex systems (see Table 2 below).[34]

There is, indeed, a deep connection between energy, organization, and complexity – and, ultimately, human behavior.

TABLE 2 (Credit: Christian Wik)

HUMAN CIVILIZATION IN LIGHT OF COMPLEX SYSTEM CHARACTERISTICS

Property	Definition	Present in Human Civilization	Example
Structural hierarchies	Having a structure consisting of many levels	Yes	Social ranking and "status-levels" present in all aspects of society whether it's politics, business, science, sports, or entertainment etc.
Spontaneous order	Emergence of order out of seeming chaos	Yes	Formation of cartels where businesses agrees not to compete* (OPEC, the Swiss banking cartel, and International Tin Council being the most well-known examples)
Apparent signs of stability or robustness	Ability to tolerate or withstand perturbations that might affect a system's functionality	Yes	Despite several perturbations such as wars, financial crisis and economical recessions, civilization has endured and remained "intact" in its functionality
Feedback loops	A pathway formed by an effect returning to its cause, which then generates either more or less of the same effect	Yes	As money in the modern economy is lent into existence by commercial banks**, the monetary system can only remain functional by the continued creation of money (positive feedback loop).
Emergent behavior	Behavior that cannot be deduced from the individual behavior of its constituents	Yes	The probability that the emergence of the Internet can be deduced from the individual behavior of the several billions of constituents that make up the global economy is next to none - hence, it's an emergent property.

*Self-organized cartel formation in a modified trust game [131]

** Money creation in the modern economy [132]

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[34] Or more specifically, Complex Adaptive Systems (CAS), in so far as human society is "built" on the aggregate actions of living beings capable, at least principally, of adaptation.

Chaisson's Energy Rate Density

Look at the graph below depicting humanity's global energy consumption in aggregate since the beginning of the 19th century and until today. Quite impressive, isn't it? If not a bit scary (depending of perspective).

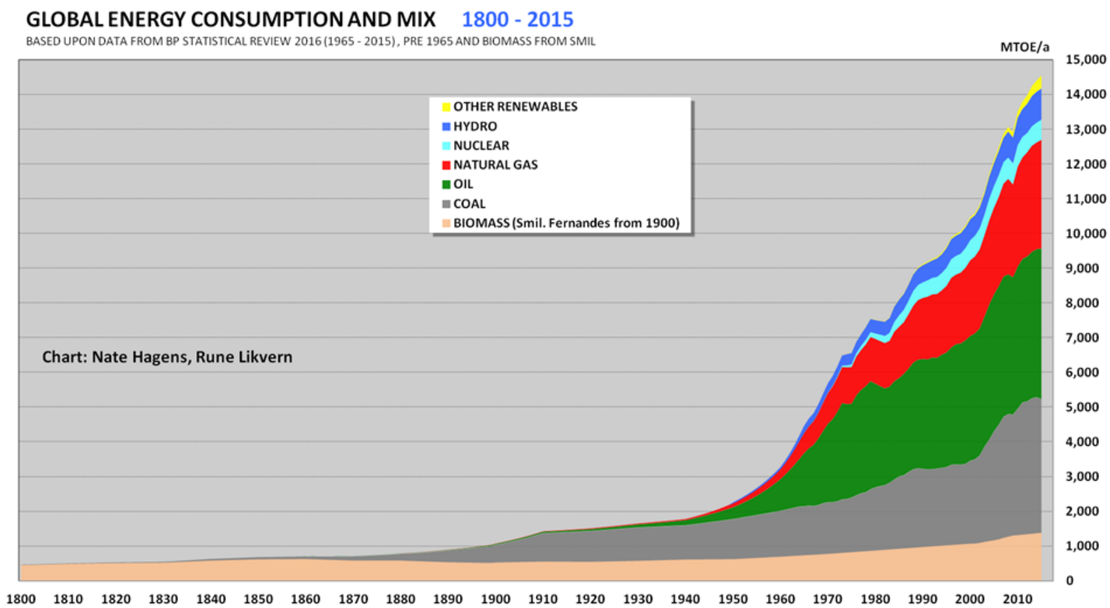

FIGURE 22 Historical development of global energy consumption (standing at 14 500 million tonnes of oil equivalent per annum in 2015) showing a colossal increase in the use of non-renewable resources such as oil, coal, and natural gas beginning in the early 1900's (Credit: Likvern & Hagens, 2016)

Now ask yourself this: Is it not striking how this gargantuan increase in energy use coincides with the rapid growth in human economic activity (measured in GDP[35]) and the subsequent increase in societal organization and complexity?

I don't know about you, but I for one think so.

"Thermodynamics", on the other hand, begs to differ: there is nothing striking about this at all. In fact, it is to be expected – at least if you ask the American astrophysicist, Eric J. Chaisson.

By using simple thermodynamic relations, what Chaisson has done – through his work seeking a "unifying cosmic-evolutionary" worldview – is to put his finger at the curious connection

[35] Since the beginning of the 19th century world Gross Domestic Product (GDP) has, according to the World Bank, increased from next to nothing (probably less than a billion) to today's 75 trillion dollars (constant 2010 US$).

between energy flow and complexity. And he has done so, quantitatively, by devising a gauge called Energy Rate Density. Now, what this gauge measures is pretty straightforward, even for those that are somewhat mathematically “challenged”: By using ergs – energy (or work) per second per gram (erg/s/g) – what this metric does is nothing more than calculating the flow of energy through any system of given mass. It’s that simple.

So, being equipped with such an “unambiguous” gauge for measuring complexity, what Chaisson did next was to apply it across disciplines – from astronomy to biology; on stars, galaxies, planets and life.

And what a revelation it turned out to be, if not downright astonishing: If Morowitz showed that the flow of energy through a system “acts to organize that system”, then Chaisson shows that energetic flows also results in evolving complexity (see Figure 23) – it might, he argues, even “drive, a least in part, the process of evolution itself [82].” Complexity, in other words, is a naturally occurring phenomenon that tends to increase with evolving sources of free energy.

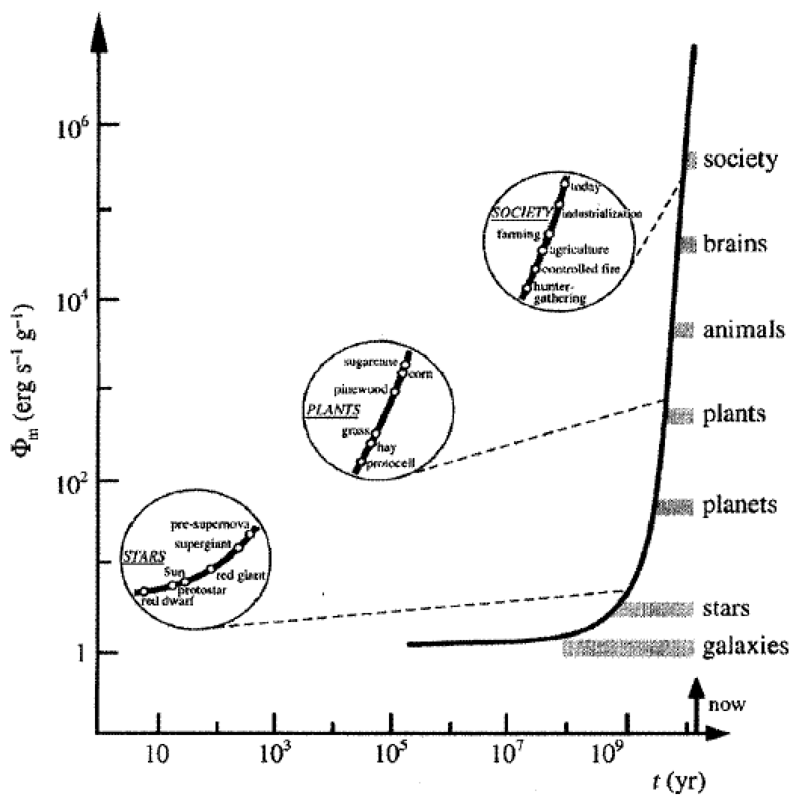

FIGURE 23 Energy per unit mass calculated for three representative systems – stars, plants and society – showing the connection between flows of energy and increasing complexity. Not to be taken as galaxies evolved into stars etc, but rather that galaxies produced environments suitable for the birth of stars, stars environment for planets, and planets for life and so forth (Chaisson, 2001)

Intuitively, there must be something to it when two scientists with different backgrounds, from different disciplines (Morowitz, biology; Chaisson, astrophysics), with different approach and different quantitative measures, both arrive at similar conclusions: that the flow of energy alone can produce "evolved" characteristics in material systems. And if you think about it, we know this to be "true" in other experimental observations as well such as the hexagonal shaped cells of the Rayleigh-Bénard convection, or the autocatalytic chemical clockwork of the Belousov-Zhabotinsky (BZ) reaction – both natural systems which, although under different energetic conditions (one pressurized by a heat gradient; the other fueled by the conversion of chemical energy), spontaneously, display properties of both structure and complexity.

So, in light of these thermodynamic "realities", and going back to the question of rising complexity and organization in human civilization (i.e., why humans in aggregate display characteristics associated with complex systems), we see that such emergence – in a cosmic evolutionary perspective – are natural properties of increasing energy accessibility and flows, rather than human agency and "cognition." According to Chaisson, "in an expanding, non-equilibrated Universe, it is free energy that drives order from disorder, from big bang to humankind." And might I add that his metric, Energy Rate Density, for sure seem to support such a claim, quantitatively.

Becoming Trapped

If energy drives complexity and organization, then complex system dynamics "allows" behavior to be "locked in", becoming trapped. And by trapped, though it sounds as if you are caught within a third party's confinements, we are really talking about a systems *inability* (hence, the term "locked in") of adapting to a changing environment without serious "operational" consequences. In that case, it is rather unsurprisingly, I imagine, since we have somewhat touched upon it already (see page 30), when I say that we are now venturing into the realm of the limits associated with complex systems. And that is exactly what we are going to do: to analyze the globalized human economy in the light of such limits, three of which are of a critical nature. As we now know, that human civilization shares all the properties of a complex system (see

Table 2, page 53), well…then it goes without saying that there is also a potential risk of being "locked in."

Limit #1 – Prone to component failures

That human civilization today, in its high tech global socioeconomic attire consists of a multitude of interconnected components, that's a given. Ask any citizen anywhere, and I guarantee that they will agree, even if it's based on intuition alone. So the question is rather one of "how many components?" Well, nobody knows that for sure, but if we are to believe those that provide us with such numbers, it has to be at least in the several of billions. Intel, for instance, in one of their "white papers", shows (by referring to data from John Gantz of IDC) that the number of connected devices and sensors in computers, cars, aviation, medicine, communications, and entertainment – in what they have dubbed "the Embedded Internet" – has increased from 2 billion in 2005, to 6 billion in 2010, and (at that time) forecasted to reach 15 billion in 2015 [83]. Or consider this peer-reviewed journal article from 2012, which graphically portrays the complex and interconnected supply-chains within the International Agro-Food Trade Network (IFTN) in 1998 [84]:

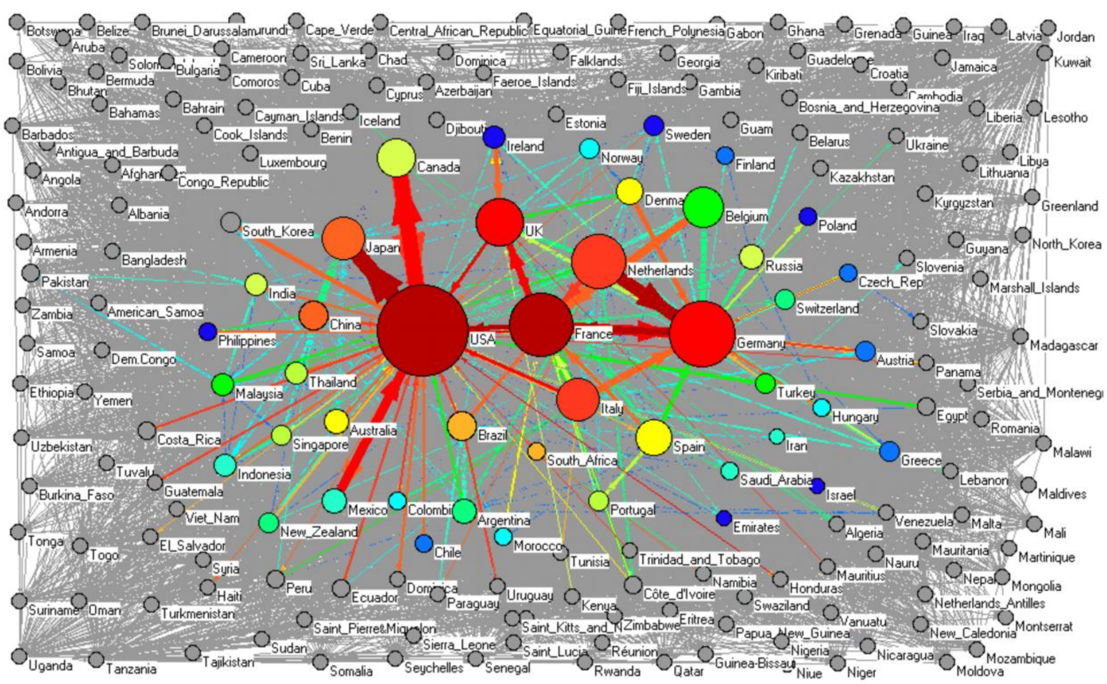

FIGURE 24 International Agro-Food Trade Network (IFTN) in 1998 (Ercsey-Ravasz, Toroczkai, Lakner, & Baranyi, 2012)

Needless to say, even if we do not know the exact number, there is evidently no shortage of components. Are there any examples of human civilization being subject to component failures, then?

Yes, as a matter of fact, there is. David Korowicz, an Irish physicist and human systems ecologist, who has specialized in analyzing large-scale systemic risks in relation to complex systems, gives us three examples of events – or "fragments" as he calls it – that has led to widespread failures in the components of the globalized economy:

1. *"The eruption of the Eyjafjallajökull volcano in Iceland led to the shutdown of three BMW production lines in Germany, the cancellation of surgery in Dublin, job losses in Kenya, air passengers stranded worldwide and dire warnings about the effects the dislocations would have on some already strained economies.*
2. *During the fuel depot blockades in the UK in 2000, the supermarkets' just-in-time supply-chains broke down as shelves emptied and inventories vanished. Anxiety about the consequences rose to such an extent that the Home Secretary, Jack Straw, accused the blockading truckers of 'threatening the lives of others and trying to put the whole of our economy and society at risk.'*
3. *The collapse of Lehman Brothers helped precipitate a brief freeze in the financing of world trade as banks became afraid to accept other banks' letter of credit*. [85]*"*

However, despite the fact that these events caused damage to the global economic system temporarily, none of them "broke the camel's back" so to speak. Why? Because the global economy (aka human civilization[36]) is a Complex Adaptive System and will, therefore, adapt to circumstances of change. And for humans, such adaptation – i.e., how humans respond to such socioeconomic challenges and perturbations – usually happens through the means of "problem solving."[37](A good example of this being the financial system, a complex sub-system[38], which the last couple of hundred years has experienced numerous economical crises of various magnitudes, some extremely severe – such as the depression in the early 1920's, the Wall Street

[36] From now on, when I refer to "human civilization" or "the global economy", I will use these terms interchangeably.
[37] "Problem solving" is easily defined as finding solutions to the problems you face.
[38] There is no denying that the financial system is, in itself, a complex system. According to the World Payments Report of 2015, the global non-cash transactions volume reached a staggering 357.9 billion in 2013 [133]. That's ~980 million transactions per day!

crash of 1929, the 1970's energy crisis, Black Monday in 1987, the Russian financial crisis in 1998, the Dot-com bubble in the early 2000's, and the Great Financial Crisis of 2008 [86]. Yet, each crisis has been mitigated either by financial reforms [e.g., birth of the U.S Federal Reserve System, abandonment of the Gold Standard, liberalization of trade, Bretton Woods etc.] or monetary policy measures [such as QE programs of Troubled Asset Relief Program, Term Asset-Backed Securities Loan Facility etc] to solve the problem of potential systemic collapse.) But there is one caveat: problem solving (usually) leads to greater complexity [87]. And greater complexity requires what? Increased flows of energy.

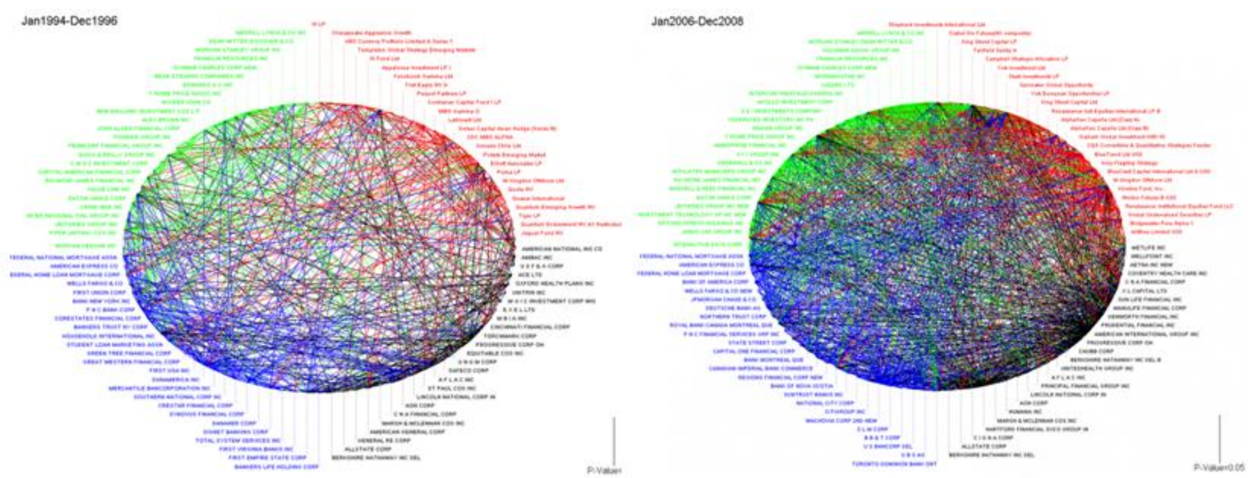

FIGURE 25 Illustration of the increasing complexity and interdependence in the current financial system. To the left, we see the relationships between various financial institutions about 20 years ago. To the right, the same relationships, only 10 years later. (Andrew W. Lo, 2013 [88])

Now, I don't know about you, but if evolving flows of energy begets complexity and greater complexity demands increasing flows of energy, this sounds to me like a situation of "self-reinforcement" – a positive feedback loop – where, if given enough time (because such conditions grows exponentially), you are ultimately faced with only two options: 1) either continue to consume greater amounts of resources and energy, or 2) "retreat" and risk the potential of catastrophic collapse. So far, given its size and complexity, it is rather obvious that human civilization has "chosen" the former rather than the latter. However, there is a problem with that, because in order to consume energy and resources *ad infinitum*, you also need access to an unlimited "external" environment. And we know from experience that that's not necessarily always the case.

Limit #2 – Relies on external environment for inputs and outputs

So, for humans, what kind of "external" environment are we talking about?

The Earth, of course. And the Sun. Together, forming a habitable environment that, in a systems perspective, is materially closed (the Earth being a finite sphere) yet thermodynamically, open (energy is derived externally from the Sun). Consequently, all earthbound systems – animate and inanimate alike – are, in principle, "sun-based" in one way or the other – whether it is directly from the sun primarily (plants, trees, algae etc.), secondarily (think of herbivores and carnivores), or tertiary (machines, cars, factories and so forth), the Sun's quantum packages are "harnessed" and "processed" within a limited materially cycling system at all orders of magnitude. And it's within these confinements that human civilization operates, today.

In that respect, although clearly limited in its external environments waste absorption capacity (the Earth being finite and all that), one could at least say – given the multi-billion-year lifecycle of the Sun – that human civilization, in theory, has access to an infinite supply of solar energy (hence the description of Earth as a thermodynamically open system). In practice though, things work somewhat differently: As ~80 percent of the world's energy supply is drawn from non-renewable resources such as oil, coal, and natural gas (see Figure 22, page 54) – resources that, if you remember, were formed in Earth's crust all the way back about 300 million years ago, in the Mesozoic eon – here, too, we see that human civilization is tapping into sources with limited environmental accessibility (and rather excessively so considering Table 3).

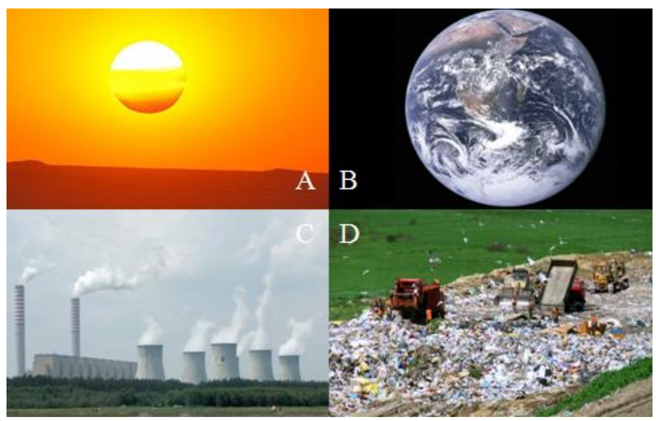

FIGURE 26 Human civilization's "external" environment for both inputs (energy) and outputs (waste). A) The Sun [134], B) The Earth (NASA, Public domain), C) Power plant [135], D) Land fill [136]

TOTAL ENERGY USE PER CAPITA 2013

SELECTED COUNTRIES (INCL INDUSTRY)

Countries	Total energy use (GJ)	GJ to kcal	kcal per day (exosomatic)	kcal buffer (exo/2500)
Canada	301	71 892 614	196 966	79
USA	290	69 265 310	189 768	76
Norway	270	64 488 392	176 681	71
Finland	254	60 666 857	166 211	66
Sweden	215	51 351 867	140 690	56
Russia	214	51 113 021	140 036	56
France	162	38 693 035	106 008	42
Germany	162	38 693 035	106 008	42
Denmark	130	31 049 966	85 068	34
Great Britain	125	29 855 737	81 797	33
China	93	22 212 668	60 857	24
India	26	6 209 993	17 014	7
Average	**212**	**44 624 375**	**122 259**	**49**

TABLE 3 Total energy use per capita in the most industrially developed part of the world showing a huge daily calorie buffer of 49:1 (world at 8:1) exosomatically (outside the body) versus the body's endosomatic (within the body) daily requirement of ~2 500 calories for biological survival. (Data from IEA, 2013)

Intrinsically, however, it is not down to environmental conditions alone to "lock in" systems behavior (although it does play its part). Within a materially cycling system there are just too many options available for initiating change – that is, until we learn that all complex adaptive systems have natural life spans where they emerge, grow, mature, and "age."

Limit #3 - Susceptible to the forces of aging (senescence)

On that account, what does it actually mean for a system to become senescent? And what is a senescent system?

One that has tackled these questions is theoretical biologist and professor emeritus at Brooklyn College of the City University of New York, Stanley N. Salthe. Now Salthe being very well versed in complexity theory and thermodynamics recognize that systems – particularly those of the nonequilibrium complex adaptive kind – have, what he calls, "three stages of development": The first stage, Salthe argues, is immaturity. This is where systems are relatively simple, small, and unformed (i.e., underdeveloped), yet energetically somewhat "hot" (by that he means that these systems require increasing amounts of intrinsic energy for growth and development). Then follows maturity, the second stage, where systems are relatively complex yet have stopped growing, and instead, by importing high amounts of gross energy, remains in a state of "self-maintenance." And finally, the third stage, there is senescence – and here I will give the word to Salthe – where "systems are becoming increasingly complex even though they are not growing in mass; they also become more metastable as their intrinsic energy throughput declines along with their flexibility, making it increasingly difficult for them to maintain themselves through adaptability in the face of perturbations [89]." In that sense, Salthe believes that senescence occurs as a result of a system being overwhelmed by information.[39]

Then how about the global economy? Is it susceptible to the forces of aging?

Physiologists James A. Coffman and Donald C. Mikulecky for sure think so. In fact, they even believe that it's becoming senescent: By taking a "Rosenian"[40] approach to complexity theory combined with Salthes' theoretical work on system "infodynamics [90]" (plus a "dash" of progressive politics), Coffman and Mikulecky argue that the global economic system, today, appears to be in a condition of (to use the authors term) "entrenched rigidity." Globally, they see the current "climate" of rising sociopolitical polarization, disinformation [91], increased digitalization[41], short attention spans (Facebook, YouTube, Twitter, Snapchat etc), and – to some extent – economic decline in the consumer economy, as signs of materializing inflexibility, information overload and energy inefficiency. Thus, by all metrics the system is appearing to be (or at least, becoming) senescent. And this is exactly why the global economy through its political institutions and economical ideology, today, works – according to Coffman and Mikulecky – as a complex system "to thwart, neutralize, or co-opt for its own ends any effort to bring about the kind of radical change that is needed to avert global ecological catastrophe and societal collapse [92]."

[39] In this context, Salthe defines information "as any constraint on entropy production, and consequently any new twist in any configuration might, in principle, function as information [89]."
[40] In reference to the late American theoretical biologist, Robert Rosen (1934 – 1998); best known for his rigorous mathematically grounded deconstruction of reductionist mechanical thought [137].
[41] Think of all the energy consuming servers supporting the "cloud."

14. An Ancient Theme

So far, whether it's in biology, complexity, or even the so-called "economy", there has been one common denominator: energy. It underpins everything. Without, there is no "work", no "movement", or "action" – neither is there any (self-)organization, and you would definitely not have seen that spectacular sight from space.

Now, at an earlier stage, before this "detour" into the aggregate behavior of human society in light of complex system characteristics (and, of course, limits), we touched upon something important: that humans, as open thermodynamic (NET) systems individually, in order to stay away from the dreaded state of equilibrium – that is, to keep "living" – must seek toward energy gradients to "feed on", degrade and exploit. Furthermore, it was argued that there seems to be some kind of, and I used the word "impetus", for energy related activities at all trophic levels. Though, the question of "why?" remained (at that time) unanswered. Until now that is, as we must consider the possibility that "life" and its energetic processes in fact relates back to one "place", the second law of thermodynamics.

A 4th Copernican Deconstruction

In his wonderful book *The Way of the Cell* biochemist, Franklin M. Harold writes: "Those who envisage a fundamental link between the thermodynamic arrow of energy dissipation and the biological arrow of the greening earth make up a small minority, and stand well outside the main stream of contemporary biological science. But if their vision is true, it reveals that deep continuity between physics and biology, the ultimate wellspring of life [93]."

Two that certainly fits Harold's description is the geophysicist-ecologist Eric D. Schneider and theorist, ecological philosopher and science writer, Dorion Sagan. In their book *Into the Cool: Energy Flow, Thermodynamics, and Life* they propose (in what Sagan denotes to a fourth Copernican deconstruction [94][42]) that life's "purposes" must be placed in relation to chemist Frank L. Lamberts modern formulation of the second law of thermodynamics which simply states that energy, if not hindered, tends to spread [48].

[42] The other three being : 1) Heliocentrism, where Copernicus showed that the Sun, not the Earth, is at the center of the solar system, 2) that humans are not made of any special matter, but of organic compounds born out of collapsing stars, and 3) Darwin's placement of humans alongside all other animals in the Earth history continuum.

With the precept that “nature abhors a gradient”, they argue – scientifically – that it’s the second law, the tendency for energy to spread, that connects life to non-life where living matter performs a basic physical task “using” complex systems to locate, degrade, and spread energy. In fact, systems that are organized “selves” such as whirlpools, hurricanes, vortices, autocatalytic chemical reactions (BZ-reaction), Bénard cells and even “techno-infested” biospheres are shown (similar to Chaisson’s energy rate density) to be far more effective at reducing energy gradients than unorganized matter [95]. Life, as a natural complex system, accelerates the process of energy dispersion as long as it does not destroy itself in the process. But it’s a delicate balancing act: expand too much energy and you risk being eradicated through overpopulation, resource shortages or pollution; use too little and equilibrium triumphs through starvation. Needless to say, the compromise between short-term rapid degradation of energy gradients versus long-term “stable” entropy production is difficult. Natural selection has for sure claimed its victims.[43] (Humans, for instance, are exceptional at releasing concentrated energy reservoirs using technology, although have yet to learn how to spread these stably [as is attested to by the increasing CO_2-levels as measured by the Keeling-curve [96]], which may come, if not to life in general, at least at their own detriment.)

However, Schneider and Sagan stresses that even though life, in the perspective of thermodynamics, has a *tendency* for exponential growth, it has learned the hard way of not to maximize energy in the short term – although so far it has done so without any human “consciousness” or political/bureaucratic institutions, but rather through other “non-conscious” mechanisms such as aging [97], death and deferred metabolism (spores, seeds, hibernation, “tun state” etc).

[43] Shown by the fact that 99.99 percent of all species in the Earth’s history are extinct [138].

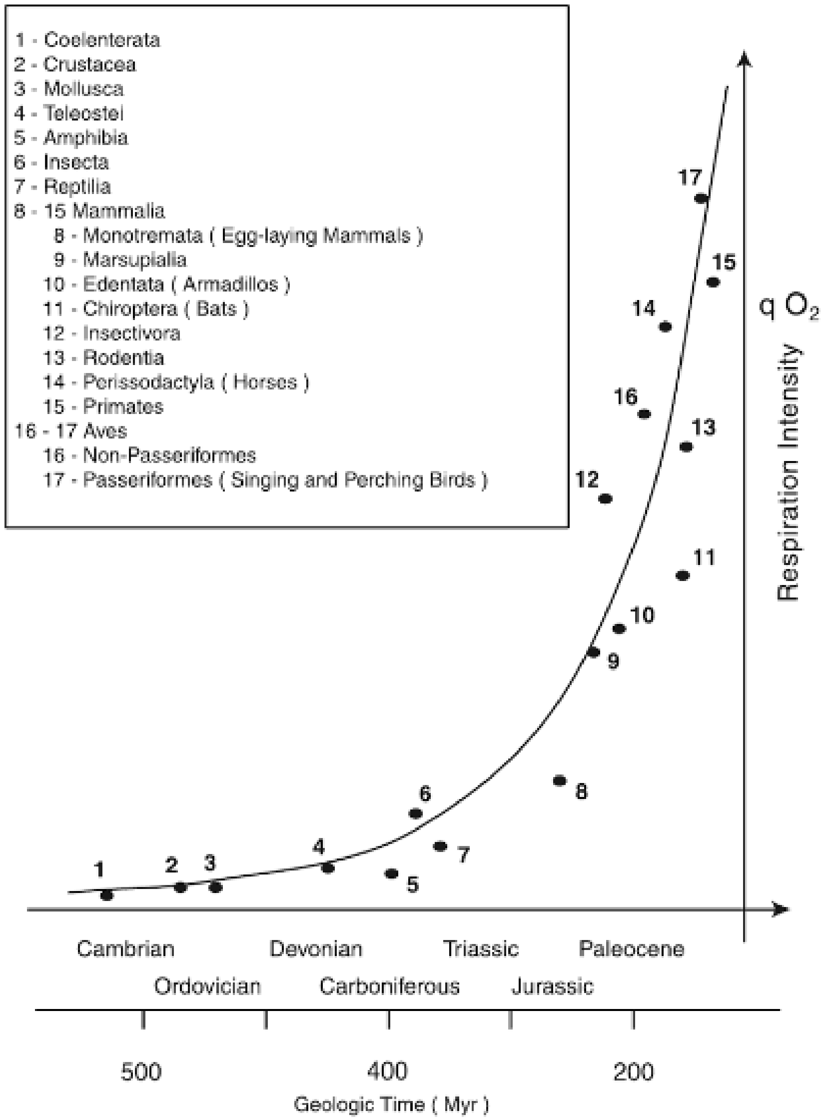

FIGURE 27 Respiration intensity of large animals over geologic time measured by oxygen utilization per unit weight. Graph shows that species with time evolved to degrade available energy gradients more intensely. (Schneider & Sagan, 2005 – adopted from Zotin, 1984)

Life "likes it cool" the authors say [98], pointing towards the fact that despite occasional setbacks through mass extinctions and other ecological disasters, life has so far throughout the Earth's ~4 billion-year-old history in aggregate been successful; becoming more biodiverse, numerous, and differentiated – thus better equipped ("sensorially") at locating, utilizing, and spreading ambient energy gradients, keeping itself "cool." [99]

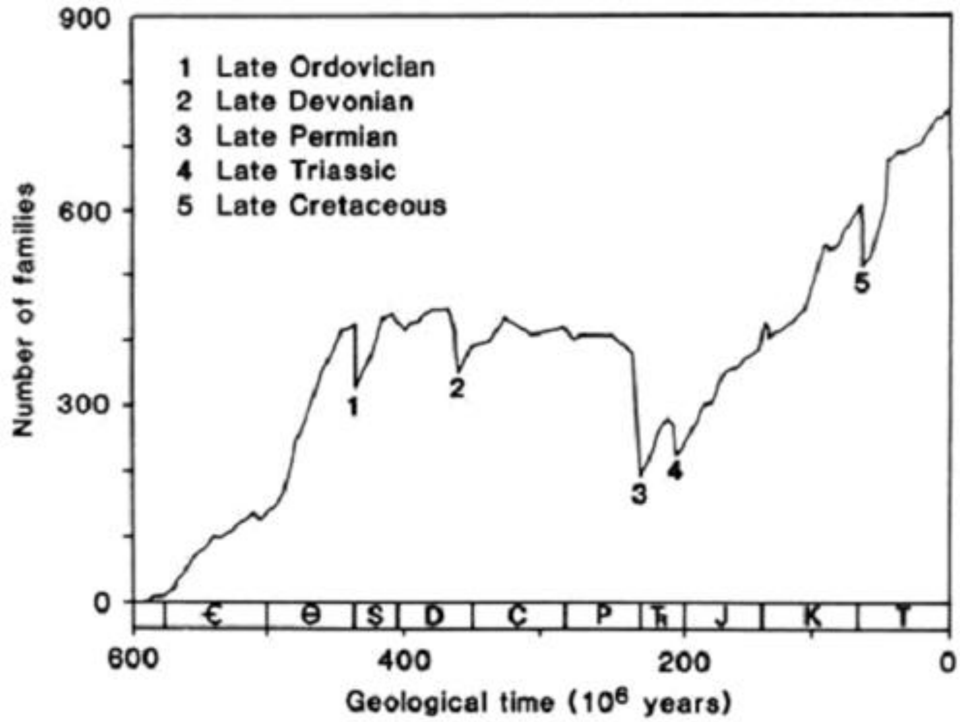

FIGURE 28 Increase in the number of marine vertebrate and invertebrate families (genera) over geologic time from the Cambrian to the present. Mass extinctions marked with numbers. (Raup & Sepkoski, 1982)

So, when getting back to the question of what is "driving" human behavior, we must confront the possibility that humans, although unique in their "semiosis", are – similar to other naturally living and non-living complex energy-spreading systems – just variations of an ancient thermodynamic theme.

So what is life?

"Life," writes the aforementioned Sagan and his biologist mother Lynn Margulis, "is the 'presencing' of past chemistries, a past environment of the early Earth that, because of life, remains on the modern Earth. It is the watery, membrane-bounded encapsulation of space-time. Death is part of life because even dying matter, once it reproduces, rescues complex chemical systems and budding dissipative structures from thermodynamic equilibrium. Life is a nexus of increasing sensitivity and complexity in a universe of parent matter that seems stupid and unfeeling in comparison. Life must maintain itself against the universal tendency of heat to dissipate with time. This thermodynamic view explains, in a way, the determination, the purposefulness of life – for billions of years it has been stuck in a pattern which, even if it wanted to, it can't get out of, of upping the stakes as it goes. For life itself is these patterns of chemical conservation in a universe tending towards heat loss and disintegration. Preserving the past, making a difference between past and present, life binds time, expanding complexity and creating new problems for itself [100]."

(You can let go of your inner-alien anthropologist now)

15. Conclusion: So Why is it so Darn Difficult?

I began this journey by asking a simple yet daunting question of why we humans, as a species, despite "knowledge" about our precarious ecological situation, still pursue a course which in the fossil record is synonymous with extinction. I then continued by telling a personal story of how I came to pose such a question, including an account of my, at that time, "unfruitful" pursuit for answers. I even drew attention to my own "paradoxical" behavior. Moreover, I argued that in order to (or at least begin to) understand our species behavior, we must (to borrow a quote from Rafiki, that "baboonish" character from the epic animation Lion King) "look beyond what we see." To me it was rather obvious that to find answers to such (to quote myself) "imposing questions pointing towards our true nature" – of "who we are", "where we are from" and to "what is our purpose"; questions that philosophers has grappled with for centuries (and still do) – it was highly necessary, as we are bodies of "life" and "history", to reach beyond mere reasons found within the basics of our psychology. To do so, to see ourselves "differently", I suggested that this must be done in broad cosmic context – particularly in light of the key properties derived from the conceptual frameworks of Biological Evolution, Complexity Theory, and Thermodynamics. (Theoretically, a somewhat tortuous journey, I imagine.)

Then I made an argument that in order to understand not only ours but any species behavior we must know its evolutionary heritage. So I gave a broad historical account of the Earth's cosmic history pinpointing the fact that evolution on Earth is a long-winded (~4.5 billion year-old to be specific) tenacious metabolic process rife with growth, selection, extinction and change (although not without direction) which we humans – although "latecomers" – are a natural part of. To further substantiate that we are "products" of an evolutionary past I provided evidence not only of our shared DNA but also that we are basically made of the same organic compounds as all other earthbound organisms (CHNOPS, remember?). I even presented the fact that "you" or "me" are not "I"'s but rather "we" – a collection of microbial symbionts. Apart from behavioral aspects rooted in biology and evolutionary history, I also argued that our behavior must be seen in the relation of us (humans that is) being nonequilibrium thermodynamic (NET) systems and that the "drive" behind our energy related activities probably stems from the fact that such systems, in order to maintain a "stable state" away from equilibrium, must import energy into themselves continuously – it is either that or "disintegrate." Moreover, we saw that the flow of energy not only “acts” at our behavioral level individually, but also at the aggregate level of our society. This I showed by providing evidence that 1) our civilizations’ rise in complexity and organization (i.e., the “self-organized” state as a complex system) is – in a cosmic evolutionary perspective – neither a result of human “agency” nor the workings of a single “master planner” but rather natural phenomenon of evolving flows of energy, and 2) that in the wake of this, as us, civilization, are “holding” properties as a complex system (a Complex Adaptive System that is) there are associated dynamics, or more appropriately, limits (such as component failures, environmental constraints, and senescence) that “allows” behavior to be “locked in”, becoming trapped. In the end though, I argued that we must consider the possibility that our behavior is a direct consequence of the connection between energy, “life” and thermodynamics. Because ultimately, being “situated” in a cosmic backdrop where energy unhindered tends to spread, there is evidence that we too – as living beings, as non-equilibrium thermodynamic systems – similarly to other living and non-living complex self-organized “entities”, accelerates the process of spreading energy according to the mandate “given” by the second law of thermodynamics.

So why is it so darn difficult for us to change behavior?

In short, because…

1. *Our behavior is rooted in “deep” cosmic history and thus susceptible to the same evolutionary forces as all other life-forms,*

2. *Our behavior (collectively as well as individually) is an “emergent property” and a natural phenomenon of evolving flows of energy and thus there is no “true” agency, and*

3. *Our behavior shows to be typical thermodynamic behavior for life-forms, and thus, although unique in our “expressions,” we are in all probability just “dancing” to the tune of an ancient theme.*

Now, consider your brain – the so-called “cornerstone of consciousness”; also known as the triune brain because of its multilayered “history”[44] [101]; which with its trillions of neural

[44] More specifically, the three complexes of the reptilian, paleomammalian, and the neomammalian (which are not to be taken as hierarchical, but rather as coevolving and embedded.)

connections is in fact a complex system [102]; a system that (according to Eric Chaisson [103]) spreads more energy per unit mass than any known star in the universe…

Epilogue: Some Thoughts…

Is our situation unsolvable?

No, I wouldn't say it is unsolvable intrinsically. For instance, in "Captivating Concepts" when I wrote about chaotic systems, I had a small segment about the famed "Butterfly effect" (Chaos Theory) which birth came when MIT mathematician/meteorologist Edward Lorenz discovered that infinitesimal differences in initial conditions produce results that are widely divergent. Now, with the universe being both chaotic and fractal in its nature, there is of course the probability of small changes (such as bottom-up strategies by "grassroots movements" etc.) having a significant impact. However, as chaos is understood as "unpredictability" in complex systems, there is always the caveat of (unintentionally) making things worse as well. That being said, whether or not it is unsolvable I would rather argue that our situation is somewhat understandable in the greater context of life and its history on Earth. We too, like other natural complex systems, accelerate the process of spreading energy according to the second law of thermodynamics. We must, however, remain humble to the fact that within the "confinements" of a limited materially cycling system and solar "excess", this is (as I have stated earlier) a difficult task: consume too much or too little energy and you risk being eradicated through Darwinian natural selection. (The late Jeffrey Wicken, for example, pointed out that life "toggles" between survival and energy degradation [entropy production] [104]). In all probability, though, we too will follow the same fate as other vertebrate species either becoming extinct (the average life-time is about 4 million years give or take [105]) or "pseudo-extinct" (speciating into another unrecognizable species). As per Carl Sagan's cold, yet precise words: "Extinction is the rule. Survival is the exception [106]."

So what should we do, then?

The short answer: I don't know. I really don't. To say otherwise – considering my findings – would be, I think, unreasonable. Although you mustn't interpret this as me saying that we should give up and "resign"; then we would just be laying down a self-fulfilling prophecy. As I mentioned above, there is chaos theory which pretty much says that we should try a million different things, yet remain humble towards the prospect that our efforts might amount to nothing (or, at worst, even aggravate the situation further.) In the greater scheme of things, though – and this gets back to my answer above about our situation being understandable – I think we, as individuals, should be forgiving towards ourselves, let go of our anger, and stop blaming "others" for the problems we face. On a cosmic "stage" too vast for our understanding, we are but natural life forms with energetic purposes. "You are," remember, as Sagan writes, "not just a political animal but a differentiated clone of nucleated cells, a collection of microbes. You are a lineal descendant of the first life, recycling a water-based chemistry full of hydrogen-rich compounds, like methane and sulfide, characteristic of the inner solar system four billion years ago at the time of life's origin, soon after the Sun turned on [107]."

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