THE ENTROPOCENE

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ABSTRACT

According to Eric Schneider and the late James Kay "nature abhors a gradient" as it seeks to degrade any and all differences that can make a difference. They also claim that life self-organized by creating a meta-order out of disordered orders, evolving as an increasingly efficient, effective, sustainable (order from order) means for degrading the huge sun to earth temperature gradient. They inject purpose into the scheme by claiming that life represents "order emerging from disorder in the service of more disorder." Or, as Jeffrey Wicken succinctly put it in "Evolution and Thermodynamics: The New Paradigm," "Organisms are remote-from-equilibrium systems that maintain their organizational structures by irreversibly degrading free energy through informed kinetic pathways acquired through evolution. Dissipation through structuring is the strategy of life." In other words, life came about as an evolving means for giving the Second Law of Thermodynamics what it wants. Entropy. In my 2015 ISSS paper, "Anthropocene as Life's State of the Art in Disorder Production: A Sustainability Conundrum," I proposed that our species collectively is disorder producer summa cum laude. We are the most efficient, most effective, degrader of gradients, producer of entropy yet evolved. Calling our epoch, "the Anthropocene" doesn't capture our essence. Our epoch is the Entropocene. We have turned the bio-geosphere from an accumulator of solar exergy ("free energy", the measure of energy's utility) as in fossil fuels, into a trapper of entropy a.k.a., global warming. Unfortunately, not only is our achievement as agent-of-entropy-in-chief not something to celebrate, our perch is being increasingly usurped by a new disorder churner on the block. Hyper-exponentially evolving technology is taking over where we leave off as it represents a far more effective, far more efficient means of degrading gradients, disordering orders including the gradients, including the orders that R us; our brains, our bodies, our face to face, family, community, societal bonds. This disorder, manifested as our increasing helplessness sans the escalating power of our technological props, our techno-prosthetics, spills over into the bio-geosphere and its ongoing degradation. My purpose in this paper is to continue exposing what's really pulling the strings backstage of such global threats as climate change and by so doing set the stage for redress to ourselves, to our progeny, to our common, non-virtual, downstream future.

Keywords: Anthropocene; ants; artificial intelligence; autocatalytic; autocatalytic organization (AO); Bénard cells; conundrum; convenience; cumulative advantage; dissipative structure; dissipative system; disorder; DNA; ecosystem; effort; Entropocene; entropy; evolution; exergy; gradient; GPS; global warming; hippocampus; kinetic pathways; long tail; machine learning; master; order; principle of least effort; robotics; Second Law of Thermodynamics; slave; sustainability; technology; technosphere; thermodynamics; tragedy of the commons; unsustainability; Zipf's Law

The Entropocene

INTRODUCTION

> "[All] technological activities, regardless of whether they rely on renewable or nonrenewable resources cause the entropy of the surroundings to increase."
>
> Gutowski, Sekulie, and Bakshi

In a nutshell, what "The Entropocene" is about is that the Second Law of Thermodynamics, to give it an anthropomorphic spin, is not only the puppet master pulling the strings backstage of the coming about and evolution of life, it has hit upon a species capable of realizing its fondest dreams, the maximal production of what it wants, entropy. But, now there is a new kid on the block threatening to usurp our throne, exponentially advancing, autocatalytically organizing (AO), technology. Because the 2nd Law will not, under any circumstances, allow the sum-total of entropy in the universe, to shrink – perpetual motion machines are not allowed – and AO technology, especially today under the impress of artificial intelligence, machine learning, robotics, nanotechnology, breakthrough gene editing (CRSPR-cas9)… represents radically shrinking entropy, something, some system, some environment, has to compensate, has to be the recipient of its entropic effluents. That something, that system, that environment is us and all we, alone and together, consume. But, before we go any further, I would like to offer an overview that appeared at the tail end of my 2015 ISSS paper, "Anthropocene as Life's State of the Art in Disorder Production: A Sustainability Conundrum," as it captures the essence of what I'm getting at:

OVERVIEW

"If [Eric] Schneider and [James] Kay are correct in their claim that "nature abhors a gradient," life both came about and autocatalytically evolved on all its myriad trees, branches, stems, and leaves… as open thermodynamic systems, with order "emerging from *disorder* in the service of causing even more disorder." To sustain the process, unlike such transient phenomena as the formation of Bénard cells,[1] or tornadoes, or hurricanes, and thus sustainably carry on gradient destruction more and more effectively and efficiently, there was Schrödinger's "order from order"

[1] The formation of Bénard cells is a case-in-point of emergent coherent dissipative structures that concentrate order in a system at the expense of its environment (Robbins, 2015; Schneider and Kay, 1995, 164). In this case the system is the highly coordinated transmission of heat energy via spontaneous emergence of convective vortices in a sliver of liquid being heated from below. When the temperature difference between the lower and upper surface of the liquid reaches a critical point, inefficient, random molecule hitting molecule conduction of heat suddenly organizes and radically increasing the flow of energy and in the process, the production of entropy. The spontaneous appearance of coherent patterns involving more than ten trillion billion (10^{22}) molecules of swirling liquid is a remarkable uptick of structural order (Schneider and Kay, 1995, 165). That order of vast numbers of linked molecules acting in concert that together form a system, represents a shrinking of entropy in the universe. But since the 2nd Law will not allow entropy to shrink all by itself, the environment of the Bénard cell system must more than compensate. Since the heat flow after Bénard cells form is much more rapid, whatever's producing the heat will be consumed much faster, producing entropy much faster, giving the 2nd Law what it wants much faster. Unlike living organisms, what Bénard cell formation (or a tornado, or hurricane) cannot do is sustain their existence through internal means, as Jeffrey Wicken points out. When the heat flow stops, the Bénard cells vanish. As he puts it, "A convection pattern is a coherent response to an external stimulus; it is not a system of internal relations that acts teleonomically to preserve itself. The central requirement of a natural [living] organization is that it be able to *pull* resources into itself through informed autocatalysis" (Wicken, 151).

as the passing on of the gene means from generation to generation of what works (Robbins, 2015; Schneider and Kay, 1995; Schneider and Sagan, 2005; Schrödinger, 1944; Wicken, 1987).

Before the Anthropocene, the complex cycles of energy, and material flows in the biosphere were so efficient at capturing low entropy / high exergy[2] solar energy as concentrated, transformable energy in the form of fossil fuels accumulated over millions of years in vast amounts. What the order from disorder to even more disorder process, sustained by the order from order passing on of success, did was sustainably capture maximal amounts of solar energy by re-emitting energy as close to usefulness exhaustion as possible.

So far so good. Aeons pass until one day we humans come along with our big brained cleverness. We capture fire, we organize food production in agriculture, allowing specialization, the exponential increasing of our numbers along with the concentrating of populations in towns and cities, we create science based medicine, and then discover and techno-extract the accumulated exergy in fossil fuels. Thanks to the doubly exponential rising accelerating returns of techno-gradients, our numbers and per capita consumption soar as we irreversibly degrade the concentrated solar exergy in a truly tiny fraction of the time it took to form (Robbins, Fall 2010).

So then, what was once a complex, ongoing, sustainable, extracting of solar exergy so efficient that bio-geospheric exergy increased over vast stretches of time, has now been flipped on its head by our species at an accelerating pace in the Anthropocene. Instead of gathering and accumulating exergy, our collective grabbing and degrading of existing sources of exergy becomes too fast for sources of replenishment to keep up. We have become the agents of entropy in the Entropocene. We give the 2nd Law what it wants.[3]

But there's more. So ravenous has the concentrating of exergy in technics become that, elites excepted for now, drawing on the knee-jerk equating of technical progress with human progress,

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[2] Formally defined, exergy is a measure of the maximum capacity of an energy system to perform useful work as it proceeds to a state of equilibrium where all differences that can make a difference have been dissipated and no further useful energy transformations are possible. "When energy does work, its quality, its exergy diminishes." Exergy also is a measure of gradients, of how far a system is out of equilibrium. As James Kay put it, "Exergy tells one about the theoretical limits on what one can do with energy. Exergy is about the potential to do something with the energy and entropy tells you what happened to that energy" (Schneider and Sagan, 2005, 32).

[3] Although the details are beyond the scope of this paper, a rough idea of why the earth, until we began consuming fossil fuels on a global scale, accumulated exergy / exported entropy can be seen as follows: With entropy defined as energy arriving or leaving divided by its absolute temperature (dQ/T), incoming solar energy is low entropy because the sun's temperature T_{sun} is high. Energy reflected back to space from the earth has high entropy because its T_{earth} is much lower. While the incoming and reflected energy must be equal, or the earth's temperature would rise, since the outgoing entropy is higher than the incoming entropy, the sun / earth system exports entropy to space. (The energy content of one high frequency solar photon is equivalent to 20 low frequency reflected photons. Incoming and outgoing energy balance requires twenty reflected photons must be transmitted to space for every incoming solar photon or else the planet will begin heating up). Its shrinking entropy both allows life to come about and fossil fuels as low entropy / high exergy energy to accumulate. By burning up vast quantities of fossil fuel in a truly tiny span of time compared to how long it took to form, and trapping reflected energy by way of the greenhouse gas emissions of fossil fuel consumption, we, thanks to our technology, are in effect trapping both energy and entropy. Rising entropy, the measure of spread out, useless, energy that's been stripped of its exergy, one of whose effects is global warming, should it cross a tipping point to out of control unstoppable planetary heating, represents a potentially catastrophic threat to not only our human future but most of life. For a more detailed look at the concepts of entropy and exergy as they relate to the sun earth system, see "Exergy-Entropy Process of Global Environmental System" (Shukuya, M., 2013).

ever "smartening" technology is degrading us as it increasingly substitutes for the mental, physical, and social exertion needed to sustain and organize our brains, bodies, and face to face relationship skills. The modus operandi is the principle of least effort under the massively advertised illusion that the more technology does for us the better.

While the degrading of human order is by no means uniform, as technology, the double-edged sword, really does do things for us, freeing us up to do and be and create what we could not do and be and create otherwise, with elites on the high end of the benefit to harm distribution benefitting far more than most because they allow the technical order to fruitfully translate empowering effort, most, unfortunately, take the path of least exertion and let the technology do the work (Robbins, 2006; Robbins, 2013). Since human effort is what sustains and develops brains, bodies, and in-depth relationships, the rising sum of technology that is eliminating those efforts is, in effect, degrading the far from equilibrium gradients in brain, body, and bond. The result is the accelerating returns of technology is creating ever escalating cumulative advantage, the rich are getting richer across the board of power, access, skill, jobs, money, at the increasing expense of the vast bulk of humanity who only think that their smartphone always at and in hand is doing it all for them (Robbins, 2013). The losing it for not using it dissipation of inner human gradients creates ever deepening addictive dependency that spills into the bio-geosphere, driving it and us, in the direction of maximized entropy, wasted possibility. Long run, as Bill Joy warned in *Why the Future Doesn't Need Us*, this is not good (Joy, B, Apr. 2000). And that's the problem.

DOING IT ALL FOR US

Farhad Manjoo is a *New York Times* technology columnist. His Thursday, May 18, 2017, "State of the Art" column was titled, "Google, Not the Government is Building the Future." Its gist was that unless the U.S. government steps up to the financial plate and invests far more than it does now in advancing technology, in particular artificial intelligence and its sidekicks, machine learning and robotics, our future will be in the for profit hands of tech giants like Google. Or as Manjoo puts it, "The artificially intelligent future [will be] built by Google ['and the other members of the Frightful Five – Amazon, Apple, Facebook and Microsoft'[4]] not the government." Though the paltry government funding for A.I. et al., research worries him, Manjoo celebrates the Silicon Valley driven A.I. future –

> the [self-driving] cars, the rockets, the internet beaming balloons and gliders, the voice assistants, augmented and virtual reality devices, and every permutation of artificial intelligence you've ever encountered in sci-fi. Technology companies aren't just funding big things – they are funding the biggest, most world changing things. They are spending on ideas that, years from now, we may come to see as having altered life for much of the planet.

Manjoo gives a thumbs up to technology allowing you to "point your phone at an object in the real world – a flower, a sign in another language, a marquee for a rock concert – and the phone will give you more information about what you're looking at;" as a plus it will allow you to press on an instantly appearing button to seamlessly buy a concert ticket. Google as an "A.I. first" company, as Sundar Pichai, Google's chief executive put it at the 2016 developer's conference, would allow

[4] I would add IBM and its evolving Watson.

the advancing A.I. smarts to provide mobile, instant, on demand translation as one facet of its escalating ability "to understand language, to see and hear, to diagnose diseases, and even to create art" (Manjoo, 18 May 2017).

In the same issue of *The New York Times*, there was another technology piece, this one by David Streitfeld, on the 2017 Google developer's conference. Titled, "Google Prepares for a Future in which It Is Always With You, and Listening," it fastened on Pichai's two-hour opening keynote address to the conference.

> "In an A.I.-first world, we are rethinking all our products," Mr. Pichai said.
> The future that the company sketched out was one in which people communicate with their Google devices by talking to them rather than typing. And the machines will anticipate trouble without your asking. They will warn you, for instance, that you need to leave for your child's soccer game 15 minutes early because there is heavy traffic.
>
> Simply pointing a phone at a restaurant would bring up reviews of it. And a search for a small product – a screw driver, say – in a vast hardware store would be enabled by what Google calls Visual Position Service.
>
> "GPS gets you to the door, and then V.P.S. can get you the exact item you're looking for," said Clay Bavor, Google's virtual reality team leader. With an audio interface, V.P.S. would be a gift to the vision-impaired" (Streitfeld, 18 May 2017).

The unquestioned assumption in virtually all articles by mainstream media technology writers is the conventional wisdom, what most consumers auto-believe, that the more technology does for us, the more it serves us, the more convenient it is, the faster it responds to our every on-demand desire, "seamlessly" – a favorite term deployed to cheerlead technology's effortlessness – the better. If you can talk to your smartphone in lieu of making the effort of typing, that's good. If the machine knows you so well that it can warn you to leave 15 minutes early because it knows there is heavy traffic en route to your child's soccer game - knowing you have a child, knowing that child plays soccer, knowing what time you take him or her to the soccer game, knowing the route you take – that's good. If you can simply point your phone at a restaurant to get reviews, that's, of course, automatically better than having to look up reviews, even if you can just speak the request, or ask someone coming out of the restaurant how they liked their meal, or just take an intuitive chance. And if you're looking for a screw driver, GPS can turn by turn navigate you to the nearest vast hardware store - no more need to go to one of those old fashioned, all but extinct, neighborhood, no GPS to find it needed, mom and pop hardware stores where the owner knew you and could tell you where to find the screw drivers and what types and sizes he had and maybe even engage in a little chat - and once there, V.P.S. guide you to the exact item you're looking for, no need to know how to get to the store by looking it up in Google, let alone an old fashioned, "clunky" - another favorite term used to denigrate the products of older technology and the "Luddites" who still rely on them - yellow pages, consult a map, no need to ask a store person where to find screw drivers, or if you're vision impaired, ask to be taken to the location. That's the "A.I. first world."

DOING IT ALL TO US

Not asked by the technology writers is what all the doing it all *for* us is, in the very act of taking over the mental, physical, and social work, doing *to* us. (If they did ask, they wouldn't be technology writers very long as the companies' marketing the products they're evaluating or the conferences they're covering wouldn't grant them access.) Because she is not a technology writer, Alexa O'Brien, a journalist who writes about capital crimes and the security state, wrote an exception to the rule *New York Times* OP ED on Amazon's flying off the shelves, A.I. driven, Echo, voice activated via the name "Alexa". [5]

With the unfortunate first name of Alexa viz a viz Amazon's activation command, Ms. O'Brien starts her piece as follows:

> It started around the holidays. My eyes began to dart involuntarily to call-outs of my name on social media.
>
> "Just ask Alexa," the tweets read. "Designed around your voice for hands-free convenience. Ask Alexa!"…
>
> [Now] I ask you — this *real* Alexa asks you — when did possessing hands become inconvenient?
>
> …When an Echo's microphones hear the name Alexa, the device wakes and records your questions and commands. You can operate any Alexa-enabled device — in your home, office or car — with this "voice-controlled computer in the cloud."
>
> You can use Alexa to order a car service or food delivery, or to book travel. You can also tell Alexa to buy other Amazon products, or to play audiobooks and music.. The growing popularity of Alexa means we may scarcely have to talk to a human again. And, on command, she talks back: Alexa will tell you the solution to math problems or measurement conversions. Have a general knowledge query? Alexa will read you the first line of the relevant Wikipedia entry.
>
> …[Promising that it is always getting smarter,] Amazon's goal is to establish a pervasive voice-activated consumer network that fits seamlessly [what else] into users' lives…Through big data collection and analytics, she will come to know us in ways we can't even know ourselves. My worry is that she will make this Alexa dumber...
>
> …Imperturbably obedient by design, Alexa appears to offer us a new level of control and choice, always on demand. The miracle of convenience allows us to romanticize this unilateralism to operate everything from our light bulbs, security systems, thermostats, music and media with a simple voice command — even as

[5] The Echo now responds to other wakeups: "computer", "Echo", "Amazon".

> we disengage from people and depersonalize the institutions that enable real connection and collective agency.
>
> …We think we're making the robots in our image, but perhaps they're making us in theirs. That's what it seems like, if you ask me (O'Brien, A., 16 Jan. 2017).

TURN BY TURN

Carrying on where Alexa (the human) leaves off, in my paper, "GPS: A Turn by Turn Case-in-Point", I framed GPS navigation systems as a case-in-point of technology as a dissipative structure in which a vastly complex organization based on a (current) constellation of 31 satellites, relativistic time dilation included, displaces its entropic effluents into the vast multitudes of humans who have become dependent on its turn by turn directions as follows (Robbins, 2011; Robbins, 2013):

> Framing GPS navigation technology as a dissipative structure affords a perspective that can help one better answer the question "but what is it doing to us?" Because GPS relieves us of the navigational effort that we once had to exert because we had no choice, it also relieves us of the mental order, resulting, in particular, in what Edward C, Tolman, in a much cited paper called "cognitive maps" (Tolman, E. C., 1948). What Tolman and his colleagues found was that rats in experimental mazes were able to take shortcuts to food goals. What Tolman surmised was that the rat didn't just learn a turn by turn sequence getting him from Start to Food. If that were the case he wouldn't be able to skip steps to get to the food more quickly, nor would he be able to find his way to the food when the experimenter subtly changed the path to the goal. In short, the rat had an internalized equivalent of the routes, paths, and environmental relationships. As Alex Hutchinson points out in "Global Impositioning Systems: Is GPS technology actually harming our sense of direction?," experiments carried out in the 1970s suggest that our human brains also form cognitive maps. Those internalized representations of routes to goals get constructed thanks to our efforts to find our way through real world environments without turn by turn, stimulus-response directions. By allowing us to get from A to B by simply following turn by turn commands, what the high technical order of the GPS system, satellites included, in effect has done is eliminate the mental order of the cognitive map that would have been created were it not for the prosthesis. If the human brain is viewed as the environment of GPS, the order in the technics displaces entropy into its human environment as mental structures not formed, which is just the way dissipative structures work.
>
> Experiments conducted by neuroscientists like McGill University's Véronique Bohbot and Toronto's Hospital for Sick Children's mouse imaging centre researcher, Jason Lerch, profiled by Hutchinson, are adding concrete evidence supporting the abstract contention that the rising technical order of GPS systems is

dissipating human mental order in those who come to increasingly use and depend on it. [6]

In an interview in her Douglas Hospital lab, located in Montreal, Bohbot told Hutchinson that although

> "the data can only be extrapolated so far, Lerch's mouse studies suggest that human brains begin to reorganize very quickly in response to the way we use them. The implications of this concern Bohbot. She fears that overreliance on GPS, which demands a hyper-pure form of stimulus-response behavior, will result in our using the spatial capabilities of the hippocampus less, and that it will in turn get smaller. Other studies have tied atrophy of the hippocampus to increased risk of dementia. 'We can only draw an inference,' Bohbot acknowledges. 'But there's a logical conclusion that people could increase their risk of atrophy if they stop paying attention to where they are and where they go…Society is geared in many ways toward shrinking the hippocampus,' she says. 'In the next twenty years, I think we're going to see dementia occurring earlier and earlier'" (Hutchinson, 14 Oct. 2009; Robbins, 2011).

ANTS

From yet another angle, one that on the surface may seem far removed, but isn't, to see what such doing more and more for us always listening techno-slaves like Amazon's Alexa, and its exploding Internet of Things (IoT) consortium, or the vast satellite enabled GPS system are doing to us and how that spills over into our escalating dissipative human footprint on the bio-geosphere, consider the only other species that enslaves its own kind, ants, and what such enslavement does to the master ants.

> The famed biologist / myrmecologist / prolific author, Edward O. Wilson, conducted experiments on master / slave ant species adding weight to the observations based on experiments conducted by Peter Huber way back in 1810. While Wilson disavows any lessons to be learned from ant slavery for our own species regarding the institution of human slavery, we might do well not to dismiss the enfeebling of ant masters that have become dependent on their captive slave ants doing the work.

[6] In one experiment conducted by Lerch, mice were partitioned into two equal groups, one of which had to use spatial strategy paralleling Tolman's route to goal via conceptual maps, and the other stimulus-response, paralleling turn-by-turn GPS navigation. Human fMRI studies of navigational strategies have found that two different regions of the brain are used in navigating via spatial strategy, the hippocampus, or stimulus-response, the caudate nucleus. What the researchers found after dissecting the mice brains was significant differences in grey matter in the hippocampus and caudate nucleus depending on the navigational strategy used. The increased volume came from "'dendritic arborization' ─ an increase in the number of connections to and from each neuron" (Hutchinson, A., 2009).

> The particular species of ant Wilson was studying was not an advanced slave maker. When their slaves were taken away, the master ants still retained a latent capacity for work that was reactivated, "rapidly taking over most of the tasks formerly carried out by the slaves…[This] latent capacity for working [is]," Wilson continues, "a capacity that is totally lacking in more advanced species of slave making ants."
>
> But there is a caveat. "The [master] workers that had lost their slaves did not, however, perform their tasks well. [Most significantly,] the slaveless ants lacked one behavior pattern that is essential for the survival of the colony: foraging for dead insects and other solid food. They even ignored food placed in their path. When the colony began to display signs of starvation and deterioration, [Wilson] returned to them some slaves…The bustling slave workers soon put the nest back in good order, and the slave makers just as quickly lapsed into their usual indolent ways."
>
> The takeaway: Yes. We're not ants, but just as the slave making ants lost the ability and willingness to do for themselves, even to the extent of perishing from hunger, so do we face the increasing prospect of a losing it for not using it future.
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> According to Wilson, "The evolution of social parasitism in ants works like a ratchet, allowing a species to slip further down in parasitic dependence but not back up toward its original free-living existence" (Wilson, 1975). The ratchet of parasitic dependence in ants has a message for us: Just because [Alexa] can do the work for us, doesn't mean that [she] should (Robbins, 2015).

SYMPTOMS

As a species, we represent the most effective, most efficient means for giving the Second Law of Thermodynamics what it wants: Entropy. We are order arising from disorder to produce more disorder, far more disorder. Evidence for the truth in this claim is everywhere one cares enough to look. A sampling:

- The so called, "sixth extinction" (Weisman, 2013; Kolbert, 2015; Ceballos, 19 June 2015; North, 23 June 2015), as in other species being driven to extinction at 1,000 times pre-human levels (Wilson, 12 Dec. 2001). According to the IUCN Red List of Threatened Species, from 1996/98 to 2017 the number of threatened species more than doubled from 10,533 to 24,431, a rise of 132 percent (IUCN Red List, 2017-1).

- "Of all the stresses that humans have inflicted on the world's oceans, including pollution and global warming, industrial fishing ranks high. For years, trawlers capable of scouring the ocean floor, and factory ships trailing driftnets and longlines baited with thousands of hooks, have damaged once-abundant fisheries to the point where, the United Nations says, 90 percent of them are now fully exploited or facing collapse" (*New York Times* Editorial Board, 3 May 2017).

- The ongoing slaughter of thousands of elephants by poachers for the ivory in their tusks (Christie, Oct. 2012).

- A remote Pacific Island that was once "one of the most pristine places on earth" now littered with an estimated 17.6 tons of mostly plastic trash as the world pumps out that much plastic every 1.98 seconds (Ramzy, 16 May 2017; Lavers and Bond, 15 May 2017).

- Beijing, where the density of dangerous PM2.5 "airborne particles small enough to deeply penetrate the lungs" rises to almost 40 times the World Health Organization's recommended concentration limit (Conner, N., 29 Jan. 2013; Hernandez, J. C., 24 Mar. 2017) and New Delhi, which, according to the World Health Organization, has the most polluted air in the world (Harris, 8 May 2014; World Health Organization, 2014; Harris, 29 May 2015, Anand, 14 Feb. 2017).

- As everyone knows, or should know were it not for powerful vested interest organized climate change denial, the earth's climate is changing (Gillis, 15 June 2015). In fact, it is changing a lot faster than computer models predicted. According to the National Snow and Ice Data Center (NSIDC), on September 16, 2012, the extent of Arctic sea ice hit a record summer minimum of 1.32 million square miles, 300,000 square miles less than the previous low measured in September 2007. The record summer minimum of Arctic sea ice and 97% of Greenland surface ice melted coupled to an average daily CO_2 level that for the first time in three million years exceeded 400 parts per million (Kunzig, 9 May 2013).

- For the third year in a row, arctic sea ice was at a record low maximum extent according to scientists at the National Snow and Ice Data Center (NSIDC) and NASA.[7]

- And not to forget what's happening to us; our shrinking hippocampi (Hutchinson, 2009; Robbins, 2011; Carr, 2014); illness from obesity threatened bodies (Nestle, 2002; Critser, 2003; Kessler, 2009; Barrett, 2010; Moss, 2013, Richtel, 2017, Ashkan, et al., 12 June 2017);[8] lead poisoned children, with increasing cancer rates, neurodegenerative disease, reproductive disorders, diabetes tagging along, thanks to 100,000 synthetic chemicals in the environment and food chain (Robin, 2011, 2014; Hernández, 12 June 2017); "Alone Together" (Turkle., 2011; Turkle, 2015) texting 'till you drop, absent presence degrading social structures (Greenfield, S., 2015; Gazzaley and Rosen, 2016); the techno-fueling of life sapping behavioral addiction (Alter, 2017); algorithm driven, rich getting richer, middle class eviscerating,

[7] While the record maximum "does not necessarily lead to a record low summertime minimum extent" the winter maximum "gives you a head start." https://www.nasa.gov/content/goddard/2015-arctic-sea-ice-maximum-annual-extent-is-lowest-on-record/

[8] A study by Ashkan, et al., published in June 12, 2017, *New England Journal of Medicine* found that in 2015, globally, nearly 604 million adults and 108 million children, 12 percent and 5 percent of the world's population respectively, were obese. Note: From an energy perspective, one might view globally rising obesity as an epidemic scale squandering of the exergy in food and health.

> cumulative advantage capitalizing (Rigney, 2010), democracy eviscerating, soaring inequality (O'Neil, 2016); artificial intelligence / robotics driven, long tail / Zipf's Law, with increasing exponent, distributed (Zipf, 1949, 1965), economies without jobs (Kroft, 13 Jan. 2013; Condon and Wiseman, 23 Jan. 2013; Ford, 2015, Nourbakhsh, July/Aug. 2015; Brynjolfsson and McAfee, July/Aug. 2015).

PERSPECTIVES

Individually and collectively we are dissipative structures concentrating order as food in ourselves, but far more significantly in the systems that service our ever escalating, ad fueled, on demand, convenience promised, media catalyzed, addiction driven wants, while displacing entropy into our bio-geospheric environments. But, as technology continues on up its doubly exponential trajectory (Kurzweil, 7 Mar. 2001), there is a twist to the story. As we dissipative structures grab order for ourselves and displace entropy into our environments, there is an emergent, thanks to an elite sliver of us, dissipative system concentrating order in itself while displacing 2nd Law demanded dissipation into its environment. The vast bulk of us.

As noted in the opening epigraph, T. G. Gutowski, D. O. Sekulie, and B. R. Bakshi observe in their paper, "Preliminary thoughts on the application of thermodynamics to the development of sustainability criteria" that "[All] technological activities, regardless of whether they rely on renewable or nonrenewable resources cause the entropy of the surroundings to increase" (Gutowski, Sekulie, and Bakshi, 2009). The rub is, whether we recognize it or not, we, individually and collectively, are the environments of technology. As the surroundings of technology, as the "masters" of doing it all for us technology, we, flattered and convenience driven humans, are the recipients of its entropic effluents (Wu, 6 Feb. 2014; Wu, 21 Feb. 2014). But unlike the undeniable harm resulting from toxic entropic effluents being dumped into rivers, oceans, soil, air, other species, under the massively marketed illusion that the more technology does for us the better, we welcome technology's effluents because they conveniently relieve us of the pain of mental, physical, or social exertion.

To better see how advancing technology, as a collective dissipative system, encapsulated in what has been called the "technosphere" or "technium" (Kelly, 2010) is using our willing brains, bodies, and bonds as convenient sinks for its entropic effluents, and how those effluents spill over into degrading the bio-geospheric environments on which our future depends, it helps to come at the systemic skullduggery from a multiplicity of perspectives.

William Ophuls

> Modern man has used technology along with energy to try to transcend nature…[It] cannot be done; nature is not to be transcended by a biological organism that depends on it. Worse, the attempt to do so will have momentous political and social consequences. Far from protecting us from painful and disruptive social changes, as the technological optimist is wont to claim, continued technological growth is likely to force such changes on us. We are, in fact, in the process of making the Faustian bargain without ever having consciously decided to do so. As a result, we appear to be traveling down the road to total domination by technique and the

> machine, to the 'Brave New World' that Aldous Huxley (1932) warned was the logical end point of a hedonistic, high-technology civilization (Ophuls , 1977, 161).

Gutowski, Sekulie, and Bakshi

With respect to creating a sustainable future, Gutowski, Sekulie, and Bakshi ask the following questions:

> [First, can] technology solve the sustainability problem? [And second, the] equally important question: can technology substitute for behavioral change on the part of humans?

Here's their explicit answer to the first and implicit answer to the second:

> The purpose of almost all technological and manufacturing activities is to decrease the entropy (increase the exergy) of the technosphere. As per the second law…this must result in an even larger increase in entropy (reduction in exergy) of the surroundings…In most technological systems, this entropy increase commonly manifests itself as environmental impact. The current approach of technological development is such that this environmental impact is usually large and negative. Thus, it may be argued that any technological development will result in negative environmental impact, and therefore achieving sustainability via [strictly] technological development may be impossible (Gutowski, Sekulie, and Bakshi, 2009).[9]

William E. Rees

In "The Human Nature of Unsustainability," William E. Rees, zeroes in on the essence of the unsustainability conundrum, when he asks: "Why does our reasonably intelligent species seem unable to recognize the crisis for what it is and respond accordingly?... The world's top physicists, ecologists, and climatologists have warned the world repeatedly that current development strategies are undermining global life-support systems, that we have "overshot" long-term global carrying capacity, and that human-induced impacts on global systems threaten catastrophe for billions of people. Yet still the dismal data accumulate with the accelerating loss of ecosystem integrity around the world" (Rees, 2010).

Rees contends that "part of the explanation for the global ecological crisis must reside in humanity's genetic endowment." That endowment, one that suited the surviving and thriving of our hunter gatherer ancestors, is now increasingly out of whack. Our genetic predispositions have become maladaptive as they are "*reinforced* by modern humanity's technological prowess and addiction to continuous material growth." He makes his case more formally as follows:

> From a systems perspective, we might say that our current "unsustainability" is a product of the natural systems that led to the evolution of *Homo sapiens* together with the resource-intensive societal and economic systems *Homo sapiens* has gone

[9] For an insightful book on why substituting technology for behavioral change is a sustainability cul de sac, see *New Yorker* staff writer, David Owen's *The Conundrum: How Scientific Innovation, Increased Efficiency, and Good Intentions Can Make Our energy and Climate Problems Worse.*

> on to create. Nature and nurture have combined to generate a perniciously intractable problem.
>
> This perspective is not rooted in genetic determinism; it by no means denies that other factors contribute to humanity's sustainability dilemma. But unless we factor in the bioevolutionary contribution, our understanding of the modern human predicament will remain unintelligibly incomplete and any "solutions" hopelessly ineffective.

One of those bioevolutionary factors is that we "are what biologists call 'K strategists' [with "K" standing] for long-term carrying capacity of an ecosystem [whose] individual survival and overall evolutionary success depend on competitive superiority at high population densities when resources are scarce. Given the intense competition for habitat and resources characteristic of K-selected species," Rees argues that "natural selection would favor those who are most adept at satisfying their short-term selfish needs," granting a selective advantage on those who seek instant gratification over those "with more conservative consumptive patterns". This sets us up for what Garrett Hardin (1915-2003) called "the tragedy of the commons" where competitors acting in their own apparent self-interest exploit a resource they all need to destruction and everyone loses (Hardin, 1968).[10] Rees proposes that "This suggests that humanity's inclination to discount the future─as incorporated into all economic planning models─has actually evolved by natural selection. Citing the research of W. W. Fowler and L. Hobbs, Rees claims that our well-honed competitive skills has enabled our species to use energy, pump out carbon dioxide, consume biomass, at rates that dwarf those of similar species.[11] "Indeed, our species may well be the most voraciously successful predatory and herbivorous vertebrate ever to walk the earth."

Continuing, Rees points out that:

> This very success is now the problem. Humans' competitive drive as K-strategists is relentless; we have no built-in "off" switch tripped by sufficiency. On the contrary, we habituate to any level of consumption (once a given level is attained, satisfaction diminishes) so the tendency to accumulate ratchets up. This is particularly so if we perceive that another social group—or country—is "getting

[10] In a variant on the tragedy of the commons proposed by mathematician, Daniel Fife, in "Killing the Goose" (Fife, 1970), a commons, as a far from equilibrium gradient, is being degraded to equilibrium, as in, say, fish stocks, "90 percent of them…now fully exploited or facing collapse"; a rainforest being wiped out thanks to clear cutting to make way for cattle ranche; a biodiversity sustaining biosphere crossing a tipping point to runaway global warming; or, for that matter, human mental, physical, and social order, thanks to technology removing the need for mental, physical, and social exertion, but someone, some vested interest, some powerful corporate interest, is making a killing, releasing "powerful changes into the world with cavalier disregard for consequences" (Bakan, 2004).

[11] According to Fowler and Hobbs, some of the more prominent differences between humans and other species involve population size and factors that are closely related. These include measures for energy consumption, biomass consumption and CO_2 production estimated for other similar species. Based on their findings, Fowler and Hobbs "reject the hypothesis that the human species falls within the normal range of natural variation among species for the measures that [they] tested, and conclude that these and other similar atypical elements of human ecology are among the primary factors contributing to environmental problems facing the world today." (Fowler and Hobbs, 2003).

> ahead" faster than we are. Even within wealthy societies, widening income gaps lead to personal frustration and declining population health, so efforts to "keep up with the Joneses" continue unabated. It complicates matters that humans' technological capacity to exploit nature now exceeds nature's reproductive capacity. As fish stocks decline, we both invent new fish-finding technologies to chase remaining schools farther and deeper and switch to alternative prey species lower in the food web.
>
> To reiterate: Without powerful restraints, humans—like all other species—exploit all available resources; the difference is that, with people, what is "accessible" is defined by evolving technology (Rees, 2010).

Jeffrey S. Wicken

The late, American ecological thermodynamicist, Jeffrey S. Wicken (1942-2002), sets the stage at the deepest levels for pulling back the curtain on the Second Law of Thermodynamics as puppet master pulling the strings backstage of our individual and collective roles as a species, including our ongoing affairs with exponentially accelerating technology, and the recognition of these roles before there can be any real world dealing with our unsustainability conundrum. The concise kernel of Wicken's thought as expressed in his 1987 book, *Evolution, Thermodynamics, and Information: Extending the Darwinian Program*, looks like this:

> In a universe where cosmic expansion maintains a disequilibrium between potential and thermal forms of energy, this means that putting smaller entities together to form larger entities will generate entropy through the conversion of potential energy to heat. Hence, the potential energy wells into which natural processes tend to flow are correlated with the buildup of structure … Dissipation is the driving force of the universe's building up or integrative tendency. Entropic dissipation propels evolutionary structuring; nature's forces give it form. (Wicken, 1987, 72)

Wicken zeroes-in on the string-pulling role of the Second Law in the evolution of life and serves to set the stage for uncovering the accelerating threat of advancing technology, in particular its autocatalytically feeding on itself power rising at the, by and large unrecognized, expense of the future of us and all our footprint stomps.

For Wicken, "natural organizations are *informed dissipative structures*, maintaining themselves by autocatalytically focusing resources into the production of their organizational relationships" (Wicken, 1987, 60). As did Erwin Schrödinger, Wicken draws on thermodynamics in his approach to the kernel of living organization and evolution seeing "thermodynamics [as a] science of systems, dealing more with process than static elements…Living systems are relationally constituted by participation in thermodynamic flows. Genes are not 'things in themselves' but ingredients in informed autocatalytic processes. Explaining the emergence and evolution of living systems in informational and thermodynamic terms does not reduce the concept of 'organism' to physics and chemistry, but shows the sources of its vitality" (Wicken, 1987, 10-11).

He claims that "The decisive factor for a thermodynamics of evolution is that the Second Law is not a force of nature like gravitation, which makes its presence felt through constraints on motions,

but a principle of irreversibility that operates *through* all such constraints and is wed to the very conditions of cosmic evolution─conditions that favor the production of entropy through associative, 'anamorphic' or building-up processes. It is characteristic of natural organizations from organisms to societies that their existences are inseparable from their operations as informed dissipative structures" (Wicken, 1987, 8).

Continuing, Wicken writes that "The basis thermodynamics provides for understanding evolutionary complexification grows from its role in connecting life with the rest of nature through entropic dissipation" (Wicken, 1987, 8-9)… "Living systems," Wicken proposes "are both *processes* and *things*. They have structures separated from environments by distinct spatial boundaries; but like Heraclitus's river those structures are in elemental flux and are maintained by the imposition of rules of form on transformations of matter and energy. Thermodynamics flows secure the structure; conversely, the structure informs the flows…Organisms might be described as *informed* kinetic structures, in which the information coded in such static structural elements as DNA provides organized kinetic pathways for degrading matter and energy. More briefly, they are *autocatalytic organizations*…abbreviated as AO" (Wicken, 1987, 17).

Wicken's "perspective on the emergence of AOs might be described as 'structuralist.' Structuralism has its roots in the social sciences, in the anthropological writing of Claude Levi-Strauss and the cognitive studies of Jean Piaget over the years. It is concerned with the problem of order, how it is achieved, and the rules governing its transformation. Piaget (1971) identified three elements in this order of process: wholeness, transformation, and self-regulation… Information and thermodynamics are both central to the themes of wholeness, organized transformation, and self-regulation. Living systems are sustained by the informed transformation of resources under thermodynamic driving forces. By this informed dissipation, they maintain the remote-from-equilibrium internal milieux on which their operations depend" (Wicken, 1987, 17).

"Complexity and entropy have complementary significances in the emergence of life. The production of one, and its dissipation to the sink of space, provides the driving force for the biosphere's complexification and generation of thermodynamic potential; the creation of the other through these negentropic processes provides the aperiodic, structured substrates from which natural selection can hone molecular information" (Wicken, 1987, 25).

"Organisms are not only systems of very high potential energies compared with equilibrium systems of the same composition; they are also extremely ordered, low-entropy systems. Low entropy, is of itself of little biological concern: inorganic crystals, after all, are the paradigm cases of low-entropy systems. The important difference is that organisms access in their structures only a tiny fraction of the configurational possibilities (loosely, configurational microstates) available to them as chemical systems, whereas crystals have virtually no configurational options. It is this remote-from equilibrium order of living organization that provides for both the existence of particular kinetic pathways and the thermodynamic potential to pull environmental resources into their production, development and propagation…" (Wicken, 1987, 36).[12]

[12] Jeremy England, a professor of physics at MIT, was celebrated in a *Scientific American Quanta Magazine* piece by science writer, Natalie Wolchover, as coming up with "a provocative new theory…[re] the origin and subsequent

THE CONUNDRUM

What possible connection can there be between these authors arguments on our unsustainability conundrum and such seemingly far removed domains like Amazon's A.I. driven, cloud enabled, Alexa, or the impact on our brains of our dependency on GPS navigation, or the helplessness of master ants thanks to near total dependency on their enslaved brethren? The answer lies in what they imply, but do not explicitly state, namely that our having arguably become "the most voraciously successful predatory and herbivorous vertebrate ever to walk the earth" is really the supreme manifestation of the evolution of Schneider and Kay's claim that "nature abhors a gradient." Life comes about and autocatalytically evolves on all its myriad trees, branches, stems, and leaves… as open thermodynamic systems, with order "emerging from *disorder* in the service of causing even more disorder'" It intimately and successfully couples to Schródinger's "order from order" as the passing on of the gene means from generation to generation of what works now driven out of whack by the ongoing "success" of our human precipitated techno-successors.

Order emerges from *disorder* in the service of causing even more disorder. As I wrote in "Anthropocene as Life's State of the Art in Disorder Production: A Sustainability Conundrum,"

> this matter of fact claim has profound implications going forward as the exponentially concentrating order in technology emerges from the disorder of state of the art not yet realized. The truth as matchup between reality and claim can be seen in our accelerating collective human impact on the biosphere during the Anthropocene. Case in point: climate change thanks to our technology enabled and driven flash fire consuming of the concentrated solar energy in fossil fuels. The innovated order in fossil fuel extraction, manipulation, distribution, and use technology (as in SUVs, power plants, container ships, cruise ships, central air conditioning, circuit boards, televisions, laptops, smartphones…) emerges from the disorder of unrealized technical means causing the disorder of both irreversible consumption in a tiny sliver of time of accumulated exergy that took millions of years to form and the global scale production of heat trapping greenhouse gas (Robbins, 2015).

Since the 2nd Law won't allow the sum-total of entropy to decrease, whenever, wherever, for whatever reason, entropy shrinks, it has to rise someplace else, in the environment, the surroundings. Advancing technology is shrinking entropy at a ferocious pace, feeding on itself

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evolution [that follows] from the fundamental laws of nature and 'should be as unsurprising as rocks rolling downhill.'" Wolchover writes that England "has derived a mathematical formula that he believes explains why [living things] tend to be much better at capturing energy from their environment and dissipating that energy as heat…The formula, based on established physics, indicates that when a group of atoms is driven by an external source of energy (like the sun or chemical fuel) and surrounded by a heat bath (like the ocean or atmosphere), it will often gradually restructure itself in order to dissipate increasingly more energy. This could mean that under certain conditions, matter inexorably acquires the key physical attribute associated with life." While England's contribution, as JoJo Brisendine writes in "New Insights on Irreversibility," is "real and substantive," and in fact adds significant weight to Wicken's insights (along with those of Alfred J. Lotka, Ilya Prigogine, Harold Morowitz, Eric Schneider, James Kay…), it is by no means out of the blue "new" as Wolchover's implies in her title, "A New Physics Theory of Life: An MIT physicist has proposed the provocative idea that life exists because the law of increasing entropy drives matter to acquire lifelike physical properties" (Wolchover, 22 Jan. 2014; Brisendine, 2014; England, 4 Nov. 2015; Schneider and Sagan, 2004).

autocatalytically with elite human help included in the dissipative system (for now). Though those who focus on the issue of sustainability generally focus on our collective impact on the bio-geosphere, unearthing the roots our collective impacts requires that we dig deeper. Rees claims at least part of the explanation for our "human-induced impacts [that threaten] catastrophe for billions of people while the dismal data continues to accumulate with the accelerating loss of ecosystem integrity around the world" is our genetic predispositions have become maladaptive as they are "reinforced by humanity's technological prowess and addiction to continuous material growth." My proposal is that the prime maladaptive genetic predisposition that lies at the heart of our unsustainability conundrum is the deep seated primal, but driven out of joint urge to preserve what was once precious, hard won food energy by letting technology do the work. Formally, as coined by the late Harvard university professor, George Kingsley Zipf, it's called "The Principle of Least Effort". (Zipf, 1949; Tétard and Collan, 2009; Robbins, 2006, Robbins, 2007). This maladaptive instinct is the direct or indirect driving force behind virtually all the ills that collectively plagues the bio-geosphere and is precipitating the dissipation of our brains, bodies, and real world societal bonding that in turn spills into escalating bio-geospheric degradation (Robbins, 2015).

Jeffrey Wicken claims that "Dissipation is the driving force of the universe's building up or integrative tendency. Entropic dissipation propels evolutionary structuring; nature's forces give it form." I will carry on where he leaves off by arguing that entropic dissipation is propelling advancing technology and the modus operandi, "nature's force' is the systematic, massively marketed capitalizing on the driven maladaptive urge to preserve energy by whatever means promises "Made Easy", whatever is differentially more seamlessly convenient, demands less mental, physical, or social exertion. Technology caters to the urge, creating dependency, feeding on addiction, rendering us more and more helpless without smartphone in hand, without apps to guide, remind, think for us, make decisions for us, do the work for us. The sustainability rub is satisfying the addiction, eliminating the human effort, creating the demand, requires more and more organization being poured into the complex technics. The process shrinks entropy by raising technical exergy. That shrinking, that rising in AO systemic technospheric evolution, by 2^{nd} Law demand must and will be compensated by displaced entropy, degraded exergy. One of the recipients of the entropic effluents, as previously noted, is the human brain, body, and social bonding. The other is the bio-geosphere supporting both still increasing billions of us humans and more significantly and asymmetrically - the few consuming far far more than the many – the global scale consumption of resources, the pumping out of greenhouse gases, the devouring of other species either directly or by eliminating their habitats.

As William Rees observed: "Without powerful restraints, humans—like all other species—exploit all available resources; the difference is that, with people, what is "accessible" is defined by evolving technology…[Our] competitive drive as K-strategists is relentless; we have no built-in "off" switch tripped by sufficiency. On the contrary, we habituate to any level of consumption (once a given level is attained, satisfaction diminishes) so the tendency to accumulate ratchets up. While Rees was focused on bio-geospheric resources, his claim applies to we human resources. Only with us, the exploitation is not being driven by us, en-masse; it is being driven by the tiny in number technical, corporate, and financial elites in pursuit of profit.

IN SUM

Okay. What I'm saying is this. Our species is the most successful of all species, present and past, at consuming existing gradients, differences that can make a difference. We, as a species, like all living organisms, individually and collectively, concentrate order in ourselves as systems and to satisfy the 2nd Law's insistence that the sum-total of entropy always increases, displace dissipated energy into the environment. In other words, we degrade the environment. And like all living organisms, we must eat to live. And we must excrete to live. Our big brains have invented technology that allows us to exponentially concentrate order in service of what we think is, or have been convinced is, our own individual and collective self-interest. That exponentially concentrating order as shrunken entropy must and will, by the 2nd Law, result in exponentially increasing entropy, exponentially degraded environmental gradients. The evidence of our species as king of the hill in entropy production is overwhelming as Pope Francis so well observed in his Encyclical Letter, *Laudato Si'*, that "The Earth, our home, is beginning to look more and more like an immense pile of filth" (I.21), a claim that meshes with the observation by ecological economist, Herman Daly, that "[t]here is something fundamentally wrong with treating the earth as though it were a business in liquidation" (Daly, 1977).

The mounting litany of environmental tolls is clear and present to anyone but an ideologue with blinders. What's far more difficult to perceive and acknowledge is that the doubly exponentially concentrating of order in the technologies we've unloosed has found a vast and convenient reservoir for its entropic wastes. That reservoir is us, not all of us, just most of us. What makes this much harder to perceive than say, the toxic effluents being dumped into a river, or the atmosphere, or the soil, is that while not even a chemical company would claim that the toxic wastes from its profitable production is doing a river good, the entropy being discharged into us, the degrading of our brains, bodies, and face to face relationships is sold under the banner of serving us. And the inner dissipation thanks to the displacement of mental, physical, and social effort needed to keep, brain, body, and relationship in shape, spills over into "the environment", into the air, into the water, into the soil, into the sixth extinction of other species, into the capturing of entropy in the atmosphere and oceans courtesy of the effluents of fossil fuel combustion. So before any manner of sustainable future can be real world achieved we need to realize that the roots of environmental redress do not lie in end of pipe solutions, in technologies that temporarily mask the real problem, namely that its evolution is our human devolution and that must be recognized and reversed.[13]

[13] For an in-depth examination of what for most is an accelerating zero-sum game as technology's evolution is being entropically compensated by human devolution, see historian Yuval Noah Harari's *Homo Deus: A Brief History of Tomorrow.* On the threat to millions of lawyers, judges, cops, and detectives by rapidly advancing "white collar" targeted, A.I. fueled algorithms, Harari writes that they might need to go back to school and learn a new profession [only] when they get in the classroom [if there is a classroom]…they may well discover that the algorithms have got there first." Though digital teachers could intimately personalize education, teaching "thermodynamics or geometry" in a way that suits [each student's] personality type, he says "it is unclear [to him], why on earth [one] would need to know thermodynamics or geometry in a world containing such intelligent programs" (Harari, 2016, 314). My answer re the need to learn thermodynamics is why there is a world containing such intelligent programs and the lives and livelihoods of millions of blue and white collar jobs and professions being dissipated to entropically pay for their emergence.

AFTERWORD

If the bulk of humanity communicated and acted with the cohesiveness of a flock of fast moving birds swooping and soaring in concert, sustainability wouldn't be a problem. If overpopulation is the problem, as a species we would get the message and go to work reducing the burden of sheer numbers. If our collective rate of non-renewable resource consumption is the problem, the species would work as a team to phase out its consumption and phase in renewable replacements. If unequal distribution of the support structures for life is the problem, those who have more than they need would immediately set about seeing to it that their less fortunate brothers and sisters around the world began getting their fair share. If the drug of ceaseless economic growth is the problem, concerted measures to reduce frivolous consumption and selective increases in needed consumption would spontaneously arise. Unfortunately, barring global catastrophe, this degree of global cohesiveness in service of sustainability is not going to happen anytime soon. Before any sense of unified purpose, an order of orders, targeting the creation of a dynamically sustaining future can even begin to be achieved the forces working against it must be fully entertained and encountered (Robbins, fall 2010). Humanity is feverishly working at cross purposes with its own survival as a species. We must understand why (Robbins, 2015).

REFERENCES

Alter, A. (2017). *Irresistible: The Rise of Addictive Technology and the Business of Keeping Us Hooked*, Penguin Press, New York.

Anand, G. (14 Feb. 2017). India's Air Pollution Rivals China as World's Deadliest, *The New York Times.*

Ashkan Afshin, M.D., Sc.D., et al. (12 June 2017). Health Effects of Overweight and Obesity in 195 Countries over 25 Years, *The New England Journal of Medicine*, DOI: 10.1056/NEJMoa161436, http://www.nejm.org/doi/full/10.1056/NEJMoa1614362#t=article.

Bakan, J. (2004). *The Corporation: The Pathological Pursuit of Profit and Power*, Free Press, New York.

Bishop, A. (21 Sept. 2012). Arctic sea ice at record low, *Earth Times*, http://www.earthtimes.org/climate/arctic-sea-ice-record/2189/

Bishop, A. (25 July 2012). 97% of Greenland's surface ice melts in two weeks, *Earth Times*, July 25, 2012, accessed January 15, 2013; http://www.earthtimes.org/climate/97-percent-greenland-surface-ice-melts-weeks/2098/

Brynjolfsson, E. and McAfee, A. (July/Aug. 2015). Will Humans Go the Way of Horses, *Foreign Affairs.*

Brisendine, J. (2014). New Insights into Irreversibility, http://www.newcriticals.com/new-insights-on-irreversibility/print

Carr, N. (2014). *The Glass Cage: Automation and Us,* W. W. Norton, New York.

Ceballos, G., et al. (19 June 2015). Accelerated modern human-induced species losses: Entering the sixth mass extinction, *Science Advances*, 10.1126/sciadv.1400253, http://advances.sciencemag.org/content/advances/1/5/e1400253.full.pdf

Christie, B. (Oct. 2012). Blood Ivory, *National Geographic*, http://ngm.nationalgeographic.com/2012/10/ivory/christy-text.

Condon B. and Wiseman, P. (23 Jan. 2013). AP IMPACT: Recession, tech kill middle-class jobs," *Associated Press*, http://www.huffingtonpost.com/huff-wires/20130125/us-the-great-reset-disappearing-jobs/?utm_hp_ref=green&ir=green

Conner, N. (29 Jan. 2013). 'Off the Scale' smog envelopes Beijing again. *Pys.org*, https://phys.org/news/2013-01-scale-smog-envelops-beijing.html

Critser, G. (2003). *Fat Land: How Americans Became the Fattest People in the World*, Houghton Mifflin, Boston.

Daly, H. E. (1977, 1991). *Steady-state Economics: The Economics of Biophysical Equilibrium and Moral Growth.* W.H. Freeman, San Francisco

Editorial Board. (3 May 2017). China Wants Fish, So Africa Goes Hungry, *The New York Times.*

England, J. L. (4 Nov. 2015). Dissipative adaptation in driven self-assembly, *Nature Nanotechnology* 10: 919-923.

Fife, D. (1971). Killing the Goose," *Environment*, 13(3):20-27.

Ford, M. (2015). *Rise of the Robots: Technology and the Threat of a Jobless Future*, Basic Books, New York.

Fowler, C. W. and Hobbs, L. (2003). Is Humanity Sustainable?, *Proceedings of the Royal Society of London*, Series B: Biological Sciences 270: 2579–2583.

Gazzaley, A. and Rosen. L D. (2016). *The Distracted Mind: Ancient Brains in a High-Tech World*, MIT Press, Cambridge, MA.

Gillis, J. (10 May 2013). Heat-Trapping Gas Passes Milestone, Raising Fears, *The New York Times*.

Gillis, J. (25 June 2015). Naomi Oreskes, A Lightening Rod in a Changing Climate, *The New York Times*

Greenfield, S. (2015). *Mind Change: How Digital Technologies Are Leaving Their Mark On Our Brains*, Random House, New York.

Gutowski, T.G. Sekulie, D.P., and Bakshi, B.R. (2009). Preliminary Thoughts on the Application of Thermodynamics to the Development of Sustainability Criteria, *Proceedings of the IEEE International Symposium on Technology and Society*, http://www.computer.org/portal/web/csdl/doi/10.1109/ISSST.2009.5156699.

Hansen, J. et al. (2008). Target Atmospheric CO_2 : Where Should Humanity Aim?, *arXiv:0804.1126v3 [physics.ao-ph]*, http://arxiv.org/ftp/arxiv/papers/0804/0804.1126.pdf.

Harari, Y. N. (2016). *Homo Deus: A Brief History of Tomorrow.* Harvill Secker, London.

Hardin, G. (1968). The Tragedy of the Commons, *Science*, 162:1243-1248.

Harris, G. (8 May 2014). Cities in India Among the Most Polluted, W.H.O. Says, *New York Times.*

Harris, G. (29 May 2015). Holding Your Breath In India, *The New York Times.*

Hernández, J. C. (24 Mar. 2017). Climate Change May Be Intensifying China's Smog Crisis, *The New York Times.*

Hernández, J. C. (12 June 2017). 'No Such Thing as Justice' in Fight Over Chemical Pollution in China, *The New York Times.*

Hutchinson, A. (14 Oct. 2009). Global Impositioning Systems: Is GPS technology actually harming our sense of direction?, *The Walrus*, http://www.walrusmagazine.com/articles/2009.11-health-global-impositioning-systems

Intelligence Squared (IQ2) Debate We are becoming enslaved by our technology, http://www.abc.net.au/tv/bigideas/stories/2014/09/04/4081183.htm.

IUCN Red List (2017-1). The IUCN Red List of Threatened Species, http://www.iucnredlist.org/.

Joy, B. (April 2000). Why the Future Doesn't Need Us, *Wired Magazine*, http://archive.wired.com/wired/archive/8.04/joy.htmlLongstaff, S. (12 Aug. 2014).
Kahneman, D. (2011). *Thinking Fast and* Slow, Farrar, Straus and Giroux, New York.
Kelly, K. (2010). *What Technology Wants*, Viking, New York.
Kolbert, E. (2014). *The Sixth Extinction: An Unnatural History*, Henry Holt, New York.
Kroft, S. (13 Jan. 2013). Are Robots hurting job growth? *60 Minutes*, http://www.cbsnews.com/8301-18560_162-57563618/are-robots-hurting-job-growth/.
Kunzig, R. (9 May 2013). Climate Milestone: Earth's CO2 Level Passes 400 ppm: Greenhouse Gas highest since the Pliocene, when sea levels were higher and the Earth was warmer, *National Geographic News*, http://news.nationalgeographic.com/news/energy/2013/05/130510-earth-co2-milestone-400-ppm/.
Kurzweil, R. (7 Mar. 2001). The Law of Accelerating Returns, *Kurzweil Accelerating Intelligence*, http://www.kurzweilai.net/the-law-of-accelerating-returns.
Lavers, J. L. and Bond, A. L. (15 May 2017). Exceptional and rapid accumulation of anthropogenic debris on one of the world's most remote and pristine islands, *PNAS* 114(23): 6052-6055, http://www.pnas.org/content/114/23/6052.full
Manjoo, F. (18 May 2017). Google, Not the Government is Building the Future, *The New York Times*.
Nicolis, G. and Prigogine, I. (1989). *Exploring Complexity: An Introduction.* W. H. Freeman, New York.
NASA, NOAA Find 2014 Warmest Year in Modern Record (16 Jan. 2015). *National Aeronautics and Space Administration, Goddard Institute for Space Studies*. http://www.giss.nasa.gov/research/news/20150116/.
Nestle, M. (2002). *Food Politics: How the Food Industry Influences Nutrition and Health*, University of California Press, Berkeley, CA.
North, A. (23 June 2015). Skyrocketing Extinctions Put Humans at Risk, *New York Times*.
Nourbakhsh, I. R. (July/Aug. 2015). The Coming Robot Dystopia: All Too Inhuman, *Foreign Affairs*.
O'Brien, A. (16 Jan. 2017). Ask Alexa? No, Hear This Alexa. *The New York Times*.
O'Neil, C. (2016). *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy*, Crown, New York.
Ophuls, W. (1977). *Ecology and the Politics of Scarcity: A Prologue to A Political Theory of the Steady State*, W. U. Freeman, San Francisco.
Owen, D. (2011). *The Conundrum: How Scientific Innovation, Increased Efficiency, and Good Intentions Can Make Our energy and Climate Problems Worse*, Riverhead Books, New York.
Prigogine, I. (1955). *Thermodynamics of irreversible processes*. John Wiley and Sons, New York, cited in Schneider, E. D. & Sagan, D., 81.
Ramzy, A. (16 May 2017). A Remote Pacific Island Awash in Tons of Trash. *The New York Times*.
Rees, W. (2010). The Human Nature of Unsustainability, *Post Carbon Institute*, https://denverpdc.files.wordpress.com/2014/09/william-rees-genes-memes-and-sustainability.pdf
Richtel, M. (12 June 2017). More than 10 Percent of the World's Population is Obese, Study Finds, *The New York Times*.

Rigney, D. (2010). *The Matthew Effect: How Advantage Begets Further Advantage*, Columbia University Press, New York.

Robbins, J. (2000). A Case for the Minimum: Least Effort as Meta Umbrella, *Proceedings of 44th Annual Conference of ISSS International Society for the Systems Sciences*.

Robbins, J. (2006). Technology and the Gene for Minimizing Effort. *Proceedings of the IEEE International Symposium on Technology and Society*, http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=4375895&queryText=Technology+and+the+Gene+for+Minimizing+Effort&newsearch=true&searchField=Search_All

Robbins, J. (2007). Gaming: The Technology / Energy Efficiency Hook, *Proceedings of the IEEE International Symposium on Technology and Society*, http://ieeexplore.ieee.org/xpl/articleDetails.jsp?&arnumber=4362232.

Robbins, J. (2008). Cannibalizing Childhood's Future as Rising to Falling Rope, *Proceedings of the 2008 International Society for the Systems Sciences Conference*, http://journals.isss.org/index.php/proceedings52nd/article/viewFile/988/318.

Robbins, J. (Fall 2010). Standing in the Way: Sustainable Future vs. Sloth, Genes, and Entropy, *IEEE Technology and Society Magazine*, 39(3): 14-21. http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5571928&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5571928.

Robbins, J. (2011). GPS: A Turn by Turn Case-In-Point, *Journal of Cases in Information Technology*, 13(2):1-18, http://www.igi-global.com/article/gps-turn-turn-case-point/54463.

Robbins, J. (2013). If Technology is a Dissipative Structure, Bring it On Deserves a Closer Look, *Proceedings of the IEEE International Symposium on Technology and Society*, http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6613117

Robbins, J. (2015). Anthropocene as Life's State of the Art in Disorder Production: A Sustainability Conundrum, *Proceedings of the 2015 International Society for the Systems Sciences Conference*, http://journals.isss.org/index.php/proceedings59th/article/view/2689 .

Robbins, J. (Mar. 2015). Ruminations on the IQ2 Debate: We Are Becoming Enslaved by Our Technology, IEEE Technology and Society Magazine, http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7064867

Robin, M-M. (2011, 2014). *Our Daily Poison: From Pesticides to Packaging, How Chemicals Have Contaminated The Food Chain and Are Making Us Sick* (Schein, A. and Vergnaud, L., trans.), New York, The New Press.

Sayre, K. M., (2010). Unearthed: The Economic Roots of Our Environmental Crisis, University of Notre Dame Press, Notre Dame, Indiana.

Salkin, A. (24 Mar. 2017). Take a Load off, The Robots That Fold Laundry Are Coming, *The New York Times*.

Schneider, E. D. and Sagan, D. (2005). *Into the Cool: Energy Flow, Thermodynamics and Life*, University of Chicago Press, Chicago.

Schneider, E. D. and Kay, J. (1995). Order from disorder: the thermodynamics of complexity in Biology, in *What is Life? The Next Fifty Years* (P. Murphy and L. O'Neill, eds.), Cambridge University Press, Cambridge.

Schrödinger, E. (1944). *What is Life? The Physical Aspect of the Living Cell*, Cambridge University Press, Cambridge.

Sukuya, M. (2013). "Exergy-Entropy Process in Global Environmental Systems" Ch. 2 in *Exergy: Theory and Applications in the Built Environment*, Springer, https://www.google.com/#q=exergy-entropy+process+of+global+environmental+system.

Streitfeld, D. (18 May 2017). Google Prepares for a Future in which It Is Always With You, and Listening, *The New York Times.*

Tétard, F. and Collan, M. (2009). Lazy User Theory: A Dynamical Model to Understand User Selection of Products and Services, *42nd Hawaii International Conference on System Sciences*, http://www.computer.org/portal/web/csdl/doi/10.1109/HICSS.2009.802.

Tolman, E. C. (1948). Cognitive Maps in Rats and Men, *The Psychological Review*, 55(4): 189-208, http://psychclassics.asu.edu/Tolman/Maps/maps.htm

Turkle, S. (2011). *Alone Together: Why We Expect More From Technology and Less From Each Other*, Basic Books, New York.

Turkle, S. (2015). *Reclaiming Conversation: The Power of Talk in a Digital Age*, Penguin Press, New York.

Wolchover, N. (22 Jan. 2014). A New Physics Theory of Life, *Quanta Magazine*, https://www.quantamagazine.org/a-new-thermodynamics-theory-of-the-origin-of-life-20140122

Weisman, A. (2013). *Countdown: Our Last, Best Hope for a Future on Earth*, Little Brown, Boston.

Wicken, J. S. (1987). Evolution, Thermodynamics, and Information: Extending the Darwinian Paradigm, Oxford University Press, Oxford.

Wilson, E. O. (1975). Slavery in Ants, *Scientific American*, 232(6): 32-36, https://archive.org/details/ants_13347

Wilson, E. (12 Dec. 2001). On Bjorn Lomborg and Extinction, *grist*, http://www.grist.org/article/point.

World Health Organization (2014). Ambient (outdoor) air pollution in cities database 2014.

Wu, T. (6 Feb. 2014). As Technology Gets Better, Will Society Get Worse, *The New Yorker*, http://www.newyorker.com/tech/elements/as-technology-gets-better-will-society-get-worse.

Wu, T. (21 Feb. 2014). The Problem with Easy Technology, *The New Yorker*, http://www.newyorker.com/tech/elements/the-problem-with-easy-technology.