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[00:00:00] Good morning. So, at the core, my work over the last 20 years has been pretty much trying to understand and communicate the intersection of thermodynamics and the behavior of a very successful social primate. Us. We tend to think of the laws of thermodynamics if we think about them at all outside of high school physics classes as something distant and mechanical.

[00:00:28] Some esoteric rules that govern heat and engines and entropy, but not something that's relevant to our everyday lives. But the more you look at them, the more thermodynamics reveals about everything, life, society, and even human behavior. Especially human behavior. So I am going to do a short series on, for lack of a better term, behavioral thermodynamics.

[00:01:08] So let's start with a very quick review of thermodynamics laws and their foundation. So energy is the capacity to do work like. Calories are watt hours. Power is energy per unit time. Watts, how fast we do things. I don't know that I'll talk about this, but net energy or energy return on energy invested or what's left after the energy it took to get the energy.

[00:01:32] It's the net, not the gross that funds everything else in society except for GDP, which is a measure of gross energy flows. Okay, thermodynamics. First, there's an obscure zero flaw, which simply states that systems can reach thermal equilibrium, and that temperature is a shared, meaningful property of the universe.

[00:01:56] Kind of profound, also kind of trivial. The first law of thermodynamics energy can either be created nor destroyed. It can only change form every time you turn on a light switch or flex a muscle, or take a breath of air, or even have a thought. It is all an energy transformation. And you may have learned about this idea through the food webs or food chains in biology where energy has transformed as it converges from sunlight and soil, up to plants, insects, insect, DeVores, herbivores, carnivores, top carnivores, and people.

[00:02:35] And when we die, the energy remaining in our bodies gets decomposed and transformed to. When we burn gasoline in our car, a portion of it is converted into power that moves a 3000 pound vehicle, but the rest of it is dissipated into the atmosphere as waste heat eventually making its way into space. The same amount of energy exists in the universe at that moment as 10 minutes earlier, but a lesser amount of useful energy exists, also called exergy with an x.

[00:03:08] then before the gasoline was burned, which leads to. The second law of thermodynamics, the second law says that with every energy transformation, energy spreads out, entropy increases, which is why the second law is called the entropy law. Entropy probably better termed energy degradation rises whenever energy changes form useful energy.

[00:03:37] Exergy degrades into waste heat. That's why a light bulb that's been left on gets hot to the touch. In fact, the degradation of energy is the great current of time itself and the reason that things decay, why stars burn out, and why all buildings and structures eventually dissolve. The amount of time we have is the amount of energy we have, from a wide boundary perspective.

[00:04:06] All right, briefly. The third law of thermodynamics is pretty esoteric. It's about what happens at absolute zero, kelvin, which is negative 270 some degrees Celsius when all motion stops. It's mostly theoretical 'cause nothing in our universe actually reaches that temperature or stillness. But it does tell us that although the universe could hypothetically approach total order, it will never achieve it.

[00:04:30] Okay, so those are the basics of the laws of ther thermodynamics. And for a long time, this is where the story ended. Three laws that describe a universe running down, cooling off, and dissipating energy over deep time. But then biologists and ecologists begin to notice and describe something strange life instead of just running down the hill of energy degradation and chaos.

[00:04:59] Seem to build complexity and increase organization somehow against this vast universal tide of entropy living systems. Create islands of order. And what er, Erwin Schrodinger called negative entropy, which was later shortened to nega entropy, I think by, pri Eugene, or maybe not, but nega entropy, negative entropy.

[00:05:24] Think of life as riding gradients from a hot to a cold temperature, from a high to a low elevation from a. Charged to an uncharged chemical state. By gradient, I mean a usable difference in heat or height or charge or concentration, that once you link the two sides, it drives a flow that you can harness for work.

[00:05:52] Like a car that's able to coast downhill gradients, create direction where things tend to move, and pressure is how strongly they move. And when a system couples itself to a gradient and allows flow, it can do work. Thermodynamics explains that These gradients. Flatten over time due to entropy. Living systems temporarily keep them steep by pulling energy through from gradients in the environment, like sunlight, chemical bonds that we have in fuel, or in a sandwich, pressure or, height like water behind a dam, and voltage and many other gradients.

[00:06:41] So how does it do that? By developing positive feedback loops through building structures that can then capture more energy from the same source or from additional sources. If energy is available, systems will self-organize to use it. Theoretically, energy can be abundant, but still useless if there's no gradient.

[00:07:03] No differential. Gradients are the source of exergy, the portion of energy that can be used, and those gradients exist abundantly throughout the universe, at least on planet earth. Alright, so what does this all mean? Moving to the meat of this, frankly. but the important part is the dessert. So, so stay, with me.

[00:07:27] Enter what some call the fourth law of thermodynamics, also referred to as the maximum power principle. Okay, first, some background here. The fourth law, by systems ecologist, Howard Odom, who was my PhD advisor's, PhD advisor, says that systems living or not tend to organize themselves to capture and use energy as rapidly as possible to do work.

[00:07:52] However, that work might be defined by the organism or system. it's not economic worth, work for a river or a gazelle. so a tree fans out its leaves to catch more sun, a river braids into channels that are able to move more water downhill. And in the human sphere, a city or a server farm rearranges to be able to route fuel and electrons and human attention, at higher and higher rates.

[00:08:24] So the maximum power principle says that if energy is available, systems will self-organize to access and use. And flatten that gradient over time when there's a usable gradient and positive feedbacks, whatever designs, behaviors and structures pull more useful power tend to outcompete their alternatives.

[00:08:48] Core, core implication of all this. In Tanzania, a cheetah runs because natural selection over millions of generations shaped it to extract maximum energy from the sun via the grass into the gazelle, into the cheetahs muscle. A financial system, a social network, and even our technologies follow this same rule.

[00:09:12] They emerge to capture and use energy, gradients, fossil fuels, electricity, even our attention and focus more quickly, more completely at the maximum rate possible, and waste heat is the outcome. Living things don't resist to the second law of thermodynamics. We ride it like a surfer does a wave. We create temporary pockets of order by accelerating the energy flow through ourselves as humans, and ourselves as a global economic system.

[00:09:46] That's the fourth law in a nutshell. Successful competing systems evolve to maximize power, the sweet spot of as much energy as quickly as possible. And yet there's a problem. in a finite world, accessing maximum power can, at certain times, like now imply less power available later. Fossil energy gives us an explosive burst of growth, but not only our fossil fuels finite, they're also destabilizing the climate that sustains their continued use.

[00:10:20] Sometimes like now, the very success of energy capture becomes the seed of an organism or a species undoing. So here's the question I want to begin to explore, and all of this is still being formulated and the puzzles are moving around in the gradients of my own mind. If life self organizes to maximize energy flow, and we homo sapien sapiens figured this out.

[00:10:49] Is there any chance we can recognize and bend this rule? Can consciousness, self-aware creatures us introduce something akin to a fifth law of thermodynamics? Imagine a system that maximizes not instant power, but power through time that learns to optimize something like endurance. In other words, a principle of maximum sustained power.

[00:11:18] Which would imply that the power in question would at some level, that have to be sustainable. When we understand that we're part of a larger energy system, that our bodies, societies, and technologies are channels for ancient and current solar flows, we at least theoretically gain the capacity to modulate it to find a new sweet spot.

[00:11:41] You could think of it as applying a time dimension to the fourth law where self-awareness allows a system to choose slower steadier flows. That preserve the gradient. Longer. Intelligence and wisdom cannot escape thermodynamics, but they might extend it. And that's the essence of what I'm labeling for the purposes of this Part One video, the Fifth Law, the idea that a species with self-awareness and wisdom.

[00:12:09] It might be able to shape the flow of energy through time, including future time. This idea is hardly a new law of physics. In fact, it's not a law at all. Just a possibility. It is a suggestion that awareness coupled with wisdom could become part of a new feedback loop in the great thermodynamic story.

[00:12:31] By awareness, I mean we are animated Stardust on a long journey of self-discovery and Trivially or not. So trivially now in this video on YouTube via this communication and others like it, we are the universe observing and understanding itself and understanding thermodynamics and envisioning the future.

[00:12:57] So by wisdom, I mean the desire and foresight to do something about this predicament. there was a famous science fiction story called The Moat in God's Eye by Larry Nivan. and Jerry, someone, which brings up, a relatively, appropriate story here. in the book, humanity Encounters an alien species called the Motis, who are technologically brilliant, biologically complex, and very sophisticated.

[00:13:32] the central discovery is that Modi biology drives unchecked population growth, and their species repeatedly expands until. It exhausts. Resources collapses into catastrophe, and then rebuilds again. The motis understand this trap better than anyone. They have developed extraordinary intelligence, specialization, and technology to help manage it, but they cannot escape it, and their biology makes restraint impossible at the species level.

[00:14:01] As a result, they deliberately isolate themselves from the wider galaxy to avoid spreading this destructive cycle to others. The core theme is that intelligence does not guarantee wisdom and growth without limits leads to inevitable collapse. ke ris and no great, insight to followers of this, this platform.

[00:14:25] But the novel ask whether any species, human or alien can escape the logic of expansion once it is embedded in biology and incentives. It's essentially a story about evolution limits and whether self-awareness is enough to override deep structural drivers. And I think it's a good parable for Earth's mods us.

[00:14:47] So when we talk about sustainability or wisdom or civilization, we're not just referring to ethics or policy, but actually physics and biology and how can we work with them rather than against, which is Nate's. Repeated your hairs on fire, admonitions on, this platform. How could the physics of awareness help us steer energy, the fifth law of thermodynamics to extend the flow of power through understanding itself?

[00:15:20] Okay, so, there's tons of nuances, caveats, and sidebars with the concepts I just laid out. And, here's a few of them. first of all. Maximum power principle versus efficiency. The maximum power principle suggests that nature does not optimize for maximum energy, nor for maximum efficiency, but for something in between power, the carbon pulse did not just provide energy, it aligned.

[00:15:48] Perfectly with MPPs bias for rate, we can see it directly reflected on our human economies around the world today. Fossil hydrocarbon consists of chemical energy bonds that are controllable in time on demand. It was not only their abundance, but their dispatchability that made hydrocarbons the default champion of maximum power principle in human societies.

[00:16:12] They allowed us to untether from the flow-based restrictions. Of all life before this point under which, we evolved and everything else did evolve. So my point here is that nature does not try to conserve energy. It tries to use it most effectively to maximize the work. And this implies that many of our popular obsessions with efficiency as the primary answer to our global constraints, are accurate with respect to physics, but ecologically and behaviorally naive, this is perhaps part of the reason.

[00:16:49] Since 1990, we've increased our global efficiency, energy efficiency by 36%, but increased our energy consumption by almost double that by 63%. If power has been evolutionary selected for, then waste has also been indirectly evolutionary selected for, okay, another caveat, A law is something that always happens and many smart people have suggested Maximum Power Principle as a fourth law of thermodynamics.

[00:17:22] Which I used to think as well, but now I see it less as a law and more as a highly probable outcome. MPP does show up in many systems, and it is often an optimal competitive strategy, and what emerges is a collective maximum power principle. But it's not necessarily an optimal survival strategy for individual species, because there are quite a few exceptions.

[00:17:46] For instance, estimates suggest that bacteria living in deep rock may make up 20% or more of all life on earth. Are they doing MPP? Or something else. Some of the most successful species are Cecile. They don't move like coral or barnacles. Now. Others are cryptobiotic. They drop their metabolism almost close to zero under certain conditions.

[00:18:12] It is even possible that life itself. Even all earth life originated on Venus or Mars and survives only because of the resilient dormancy and panspermia within the solar system. While all the high throughput maximum power principle species on those planets went extinct. It's possible. The point is that power alone misses a crucial concept, what I'd call move quality power gives you more game moves.

[00:18:40] In the game of life, but those moves might be clumsy or dumb, or dead ends or masterful. There are spiders with very negligible metabolism that prey on birds with enormous power, throughput. Think of the quality of the game, move of a rattlesnake, low power, high effectiveness. Power matters. You need it to play the game, but after a certain point, it mainly buys you more turns, and I'm suggesting better turns.

[00:19:12] in many circumstances, perhaps. The human one upcoming is even more important than more turns. This is where the fifth law, or, the aspirational fifth law fits. It, aligns with the non inevitability of the fourth law. We can imagine systems evolving around survival rather than throughput. And over long time scales.

[00:19:36] Evolution could favor such high quality moves where raw power ceases to dominate and win the game board. another caveat, some of you may be thinking that this fifth law of thermodynamics, rhymes with the kishev civilization scale, which ranks civilizations by how much power they can tap. Type one for planets.

[00:20:00] Type two for, Stars and type three for galaxies. These concepts do rhyme in the sense of long-term civilizational aspiration, but kha is about energy quantity. While the fifth law is closer to a stewardship rule, Watts through time with some semblance of stability, a wise species. May choose not to climb the ladder.

[00:20:28] If the ladder is ultimately leading them off a cliff. It could be that truly successful species do not build Dyson spheres in space. Conscious species that survive for hundreds of millions of years would likely have chosen stability over maximum power simply 'cause That's how you would persist that long.

[00:20:50] Kish Shev thinking, with the techno optimist, crowd has no behavior in it. It's agnostic about psychology and governance or culture. It's purely about power. The fifth law premise is explicitly behavioral thermodynamics. It asks whether norms or foresight or self-regulation might be able to modulate flow.

[00:21:16] As an aside, I think Kish chef civilization scales are, pretty much bs. It's about the huge misnomer that tech is the universal benchmark for intelligence and worthiness and, the ultimate coinage, in a universe that max power always overwhelms wisdom. Seems likely, but not inevitable. okay, so.

[00:21:44] As I think more about this, the concept of human behavioral thermodynamics probably deserves its own follow up, which I will do, but here's some. Preliminary, mid-December thoughts, thermodynamics operates at planetary and global economic scales, but also at the level of the individual human. Your brain is about 2% of your body weight, but uses roughly 20% of your resting energy neurons burn glucose and oxygen.

[00:22:19] To make a TP, which fuel the movement of charge particles across membranes in your cells. This is how a thought. And action happened. This just happened as I said this sentence. Gradients are usually discussed in ecology and biophysics, but in daily life, each of us is a metabolic gradient, and we also live and act inside behavioral gradients from boredom to stimulation, or uncertainty to certainty, or low status to higher status.

[00:22:49] These are all gradients. We move towards opportunities that promise, higher energetic return for effort. And we seek tools and habits and technologies that let us do more faster and with less friction. And when millions or billions of humans interact, those individual gradients, couple. Together and what emerges is something larger than any person.

[00:23:15] A metabolic economic, Superorganism, cities, markets, supply chains, financial contracts, media platforms. These are all self-organizing physical structures whose primary function is to increase the rate at which energy, materials, and information flow through this system. This human metabolic Superorganism has existed already for thousands of years, but as viewers of this platform know, only recently has it been shaped by something new, the mother of all gradients, the carbon pulse, this one-time rapid extraction and combustion of hundreds of millions of years of stored sunlight over just a couple centuries resulting in unprecedented power across individual.

[00:24:04] And societal scales. And this pulse has subsidized new behavioral gradients, status tied to throughput, attention harvested by always on platforms and algorithms and convenience as a perceived default, right? And once this pulse was liberated, something like the world we see today was inevitable. In my opinion, this is because self-organizing systems are not intentional.

[00:24:35] They emerge in a complex, multi scaled selection process among many other possible systems designs. And the current prevailing systems are those that fit the maximum power principle. And from this perspective, capitalism looks less like an ideology and more like an emergent thermodynamic behavior. It is the collective expression of the maximum power principle acting through human culture.

[00:25:05] Capital flows towards activities that accelerate throughput, so firms and corporations that move energy matter or attention faster. Tend to outcompete those that do not financial profit wages, salaries. quarterly earnings in this framing is a signal pointing to where power density is increasing. And on the other side of the coin, financial losses mark places where gradients are being accessed too slowly or inefficiently.

[00:25:37] This is why capitalism, or. behavioral thermodynamics on mass for a social primate relentlessly expands into new domains, fossil fuels, electricity, data, human attention. Each new gradient becomes a new arena for power maximization, which for better or worse, AI is now such a new domain. The system does not ask whether this is wise.

[00:26:02] It merely responds to existing gradients incentives and feedbacks, and seen this way. Many, if not most of our social and ecological crises are not moral failures. They're thermodynamic overshoots. The economic Superorganism discovered extraordinarily steep gradients and organize itself to exploit them as rapidly as possible.

[00:26:29] Global heating and the squeezing out of other species is what this all looks like at a, planetary scale. Okay. deep breath. So I have my PhD in natural resources with a specialty and energy. Like I always thought about thermodynamics from, perspective of the sun or oil or electrons or batteries, and I never really thought about it from a wider boundary perspective of.

[00:27:06] Thermodynamics within my body and my brain and my own individual behaviors and the thermodynamics of how my body and yours interact with others in a social setting. And, just in the last couple weeks I started thinking about this and I'm still thinking about it. So treat this, frankly, as, kind of the first.

[00:27:34] step in the wider boundary behavioral thermodynamics. So the maximum power principle does appear to be a deep tendency of complex systems, and when gradients exists, and feedbacks allow. And right now the carbon pulse is the mother of all gradients with feedbacks systems maximize throughput.

[00:28:00] Humans didn't invent this rule. We are just expressing it in spades, but unlike rivers, forests, or cheetahs, we are aware of the rule at the same time that we're participating in it. I think that counts for something. I choose to believe that this might matter. So the question here. that I pose today is not whether thermodynamics can be broken because it can't, it cannot be broken.

[00:28:34] The question is whether consciousness can alter which outcomes arrive during these thermodynamic constraints. So the hypothetical fifth law that I'm suggesting here, I'm using the term, it's not a guarantee, it's an aspiration. it's a possibility. it's a tiny possibility that a self-aware species could prioritize sustained power over maximal power.

[00:29:09] And if such a principle can emerge anywhere in the universe. It would have to emerge in a species that understands energy, entropy, and its own role in those flows. Whether humanity can do this or even some subset of it remains an open question. The universe runs on energy transformations, and through us, it also experiments with reflection and perhaps with enough understanding behavioral choices of something other than power, or at least not only power, might come about.

[00:29:53] That was a whole lot of complexity, and density. That I just dropped on you. this will be our last content for 2026. I need a long winter break. among other things, I'm gonna have knee surgery in early January. With that, thank you for supporting this program for being part of the community.

[00:30:19] I will talk to you next year. Happy Solstice, happy holidays and enjoy the seasonal gradients all around you. Or at least notice them. Talk to you soon.