

*What Entropy Tells Us About
Our Potential*

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Growing up, I was surrounded by science, and though it does not captivate me quite as much as it does for my parents, some of the very basic building blocks of our universe seem to have stuck with me. One of my favorite things is the concept of entropy in thermodynamics, because I think that it is a good model to build a life philosophy out of. In popular science, entropy is just viewed as the gradual increase of chaos, randomness, disorder and lack of control in a system. This popular view is often argued to apply to human society to show the need for control.

But what resonates with me personally is what entropy really is in thermodynamics. At the most basic level, entropy is directly related to the number of ways you can arrange a system. Moreover these systems will expend energy in order to increase their options. This is just like how some people will trade effort to maximize opportunities, to try and open more doors for themselves rather than close them. Entropy is a calculable and countable trade off between work, energy, and possibility.¹

I have embraced this philosophy in my life. It is empowering and encouraging to know that my own effort can create more opportunities and more pathways for me to take in life. My final piece will illustrate this, to remind people that if you want something in life that you can make it happen. If there isn't a door open, find a window, go through the back door, crawl out the chimney, find a way to make a new path, because where there is a will there is a way.

I hope this piece will speak to not just young adults, but to everyone trying to carve their path in the world. I want to give the message that it is never too late to change your mind. As a person who is faced with the looming decision of college next year, I become more and more curious as to how this decision will change my life. This makes me wonder how other people look at it. Is it seen as just the next step along a straight path, does it feel like leaping across a chasm to run free on the other side, or do the choices in college only feel like a mess of confusion.

For me it is an easily reachable opportunity, yet full of wonder and opportunity. It is a privilege and a right of passage for many young adults looking for a higher education, a new place to go, a new group of people, and new things to learn and try. College will change my life, no matter where I go, no matter what I study; it will lead me to an infinite number of new possibilities and knowledge. But these possibilities come from my choices in doors, not from the college itself. All the choices I am making now are opening and closing doors. The desire is to choose what doors wisely, so that when one door closes, at least one more opens. I know my choices determine this in a cause and effect manner. I get to, have to, choose which doors to close, and with effort and energy can open what doors I want. Perhaps it is easy for me to sit here and dream about going off to a new exciting school in new exciting directions, because all that is required of me is to do well enough to get accepted. But I know for others my age, this idea of spending effort to open doors and therefore possibilities is foreign.

As I've seen in others, college is a life preserver they are trying to grab, and for some a seemingly impossible dream. Whether it is the financial stress, or academic performance worries, there can always be more things that go wrong than things that go right. It is not as simple as choosing just any door, each door comes with a different set of challenges that go beyond turning the door knob and walking to the end of that path. There are paths that we get stuck on, and feel we can't get off of. There are doors that open out to stormy weather. The first choice should not be the only choice – you have to work to keep many paths open.

I want to explore how much our perception changes the paths we see ourselves going down, or the ones we find ourselves wishing we could. I want to know if it is possible for the

people who have everything going against them. I know the statistics are not always in the favor of those who take the path less traveled, but somehow people do make it and beat the odds. Which door did they open, and how did they find their way? I am curious: how much power do we get over our lives? Are we doomed by our environment or circumstance? Can we overcome the place we started from?

How does the concept of entropy help us make our choices? For one, entropy tells us that we have the power to create more chances by putting in our energy or effort. Moreover, it offers the vision that your personal effort can open up new horizons for yourself, and that the universe is behind you in your efforts. Being a teenager today, everywhere I turn the message I am being sent, whether subliminally or outwardly, is that I must work myself to the bone because this time will define the rest of my adult life. But is putting your nose to the grindstone and working hard at something sufficient? Everyone is harping for us to maximize our opportunities, yet also to make a choice now and focus on it. That is choosing one door, and crawling down the hall on the other side of it. So what does entropy tell us that can help?

Entropy is well defined in physics, although often misunderstood. In the disciplines of thermodynamics and statistical mechanics, entropy is a measure of the number of states a system can arrange itself in, a measure of multiplicity related to the state of the matter. If that state of matter can be accomplished in many different ways, then the system wants to be in that state. If the system is two dice on a table, what is the most likely state it will be in? Well, having the two die add to seven is more probable than having snake-eyes (two) because there are six different combinations that can give you seven and only one that produces two. If you rolled a million dice on a table, it would be very unlikely to have them all come up ones.

But that is just probabilities, useful in Vegas casinos but maybe not in the rest of life. The power of entropy in physics comes through the Gibbs Free Energy, $G = H - TS$. Here H is the enthalpy of the system, representing the work that goes into making the system, T is the temperature, and S is the entropy. In a cup of water, the enthalpy H comes from the bonding of the water molecules together, each trying to hold on to all the others. If you only consider the bonding energy, it will all remain liquid.

But, at any non-zero temperature, increasing the entropy will lower the Gibbs Free Energy, and the system will go down that path instead. If the cup of water is placed in a big box, will all the molecules stay in the cup, snuggled up against each other? No! But it is hard to make liquid water into vapor (microwave ovens notwithstanding) – you have to rip it out of a happy chemical embrace and kick it out into the air. Why would any molecules want to do this? Because of entropy – spending some effort to send molecules out into the vapor returns huge amounts of entropy – those molecules can zip around inside the big box and explore a huge new territory. Not all of them leave to fly around – there is a balance between molecular snuggling and exploration of the unknown. We might not like the humidity generated as water explores, but the message of entropy is not bland probabilities – it is that a little effort can let a person explore, develop, grow, and achieve. You need to keep exploring, seeking out new directions and opportunities, maybe not to follow that one path, but to be aware of everything that is out there.

In popular science entropy is seen as randomness, chaos, and disorder. It is not considered a good thing that a system over time will acquire some amount of disorder. When humans look at the world, the profusion of flora and the fauna, what we often see is wild growth, tangled forests, wild animals. It all seems very anarchic where we don't see examples of order. There seems to be a primal urge to beat back the wild unknown, to create instead neat orderly gardens. But the Second Law of thermodynamics states that the entropy of the system never

decreases without significant work. Being in thermodynamic equilibrium means there will be entropy.² The Second Law also introduces us to the ‘arrow of time’ in physics and tells us that entropy in our universe can only move in one direction, that it can only increase.³ This means that new factors and variables occur in a system evolving over time, without the help of an outside force.

What does this mean for us as individuals and as part of societies? How will we build our society? Who and what makes our culture? Nature has systems and structures that work, the universe obeys physical laws, including entropy. Can we look at things like entropy, and gain a little insight into what we can expect from ourselves, and for our world?

How does one turn this into a metaphor for life? Eric Zencey did a very thorough job of laying out the different ways people over time have synthesized and interpreted entropy. He states the fact that many have seen the “law of entropy” as being the most metaphysical law of nature.⁴ People find comfort in making connections between culture and our society on the one hand, and nature and the logical order of science on the other. But entropy is not necessarily a comforting thing to create metaphors from. Entropy should scare us senseless, because if the popular interpretation applies to our society and our global community then we are doomed. Entropy can only increase; the complexity, multiplicity, and disorder can only grow. Yet humans love order; we fight wars solely for the purpose of having more control over the earth. Maybe we are attracted to the concept of entropy because it allows us to justify the not so pretty parts of society. It’s a way to explain the chaos and the sometimes not so random acts of horror we can experience in this world.

We should instead embrace the real meaning of entropy: keep looking for more doors to open, more pathways to follow balanced against the comfort of our society.. Is it in society’s best interest that people do anything that they want? Totalitarian leaders would say that that is the least efficient and most in-correct way to organize society – they want everything lined up in a neat, tidy, determined order, all of the water obeying orders and staying in the cup. Yet, like the molecules leaping into the empty void, history has shown that groups of people don’t take well to having their lives be dictated for them. We could have saved ourselves a lot of lives and a lot of time if either the desire to rigidly control didn’t exist, or people in the past hadn’t thought it necessary to exert displays of total control over groups of people. So then who gets to decide where the line gets drawn? We as individuals have free will, and can decide for ourselves how much exploration we want to do.

I think this is why democracy functions really well as a political system. Anarchy may offer a lot of paths, but there isn’t a stable place to hold onto. Giving everyone freedom means some will stay close to home, and some will roam widely in their search for a path and meaning to their life. Because we all have all these different choices, and even though there are people who like or do very similar things as one another, no two people are the same. Democracy allows the people who are on different paths in a given country to still come together and decide as a community which paths we agree not to go down, and what will happen to those who do anyways. It decides which paths we value as a whole, and which will yield the most monetary or social reward in that given culture. I guess it’s rather unfortunate for those whose wish was to become a really good serial killer, but you can’t please everybody.

Can democracy be corrupt? Yes, because wherever humans are involved there will be corruption and there will be people who lose more than they win. Those are, after all, possible paths and some will open that door and proceed. Politicians take bribes, people make mistakes, and sometimes the community you live in doesn’t approve of the same paths you do. Does this

ultimately limit people? Yes, but it is not a rigid absolute limit – entropy ensure there is fuzziness and disorder.

Individuals expending great effort to open doors and discover and follow new paths have generated change in our society. Over the last century, women's rights have been evolving. I still remember my mom telling that when my grandma got married, she couldn't get a credit card without having a husband to sign for it. Women couldn't vote for a long time, and that left a gap in laws that left women unprotected. Still to this day women aren't paid the same as men for the same jobs.. Yet we have opened many doors.

The Little Rock Nine fought hard to open and keep open the school doors of their high school in 1957. Martin Luther King's leadership of a long struggle opened the door for many others to peacefully stand up and speak for what they believed to be right. We are in the midst of a sea change in how our society views gay marriage, as more and more cases are brought into courtrooms and more people grow up accepting of those who love whomever they choose.

This is how our democratic society works. It only takes one person to see an injustice in the ways that our society or government is locking doors. When that one person, exploring paths out at the edge, sees a locked door, they can break it down and open up more options. If enough people want the road block gone, then give it about 10 years and pretty soon that new path will be a safe and accepted one. It only takes one person to see a closed door stopping them that they believe shouldn't. It's comforting to know that our government can adapt, even if very slowly, to the changing mindsets of the population it is in charge of. There is strength in numbers, and together we can open many more doors. There is always a choice that can be made, all it takes is some effort to create or open these doors. The possibilities are open-ended from there, the doors open and we can all choose our own path to go down. But entropy says it will take energy and seeking to find those doors.

At the end of this argument is the fact that there is always a choice that can be made. We are never truly stuck, doomed, or hopeless. We can take comfort in the fact that we know that entropy's end game is to end in a state of equilibrium. This means that even when we are at our lowest lows in life, something better can be made out of it. Just as we cannot control entropy, there are things that are out of our control. We can't control what doors will already be open for us, but we can choose the ones we want to go through, we can strive to find more paths. If you're doing something you love, well then any downsides of that path become a little more bearable.

That old phrase that "where there's a will there's a way" is true. Humans were created with free will for some reason, and we get to find out for ourselves as individuals what this means to us. There are endless possibilities, and entropy tells us so. William Ernest Henley nailed down this concept in his poem "Invictus":

*It matters not how strait the gate,
How charged with punishments the scroll.
I am the master of my fate:
I am the captain of my soul⁵*

You are never confined to the doors that are in plain view. There are always a few more hiding if you look a little more closely, and they will be within reach. The harder you work, the luckier you get. That luck is choosing the doors you open.

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Endnotes

¹ Custer, Jonathan

² Atkins, Prof. Peter W. "Thermodynamic Principles."

³ Sardar, Ziauddin, Ziauddin Sardar, and Iwona Abrams. *Introducing Chaos*.

⁴ Zencey, Eric. "Some Brief Speculations on the Popularity of Entropy as Metaphor."

⁵ Henley, William. "Invictus"