

Energy, Entropy, and the First Law of Thermodynamics
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For my freshman students, I simplify the First Law of Thermodynamics through song. They listen to a diddy by Flanders and Swann that entertainingly sticks into their minds the idea that heat is work and work is heat. Heat energy can't be created or destroyed; it is always, instead, *conserved*. They come to really understand it though when they make the energy from a burning Cheeto warm up a tin cup of water or feel an exothermic reaction through a test tube onto their tender skin. They experience it unconsciously in the hallways, too. It may look different, but the glow of love finally requited or the burn of harsh words delivered over social media have all the signs of heat energy being conserved and passed along.

All this heat, however, is just a spin-off from the big daddy of energy laws: The Law of Conservation of Energy. What's that? You don't remember everything you were taught in 9th grade? Allow me to take you on a journey into your past to resurrect the memory. There really is not one person responsible for the Law of Conservation of Energy. Instead, it was quite a few different people working in different fields at different moments in history and coming to the same conclusions. Empedocles was one of the first to say that, "Nothing comes to be or perishes" back in 460 BCE. Galileo represented this Law through his interrupted pendulum. He showed that inertia, or the energy of motion, involves changing potential energy into kinetic energy and back again. In *Principia*, Sir Isaac Newton explored conserved energies through force and momentum. Emelie du Chatelet advanced the notions of potential and kinetic energies through the model of metal balls dropped onto soft clay. She was one of the first to mathematically explain how energy is transferred. Karl Friedrich Mohr gave the Law traction when he wrote that, "[Energy] may appear... as motion, chemical affinity, cohesion, electricity, light and magnetism; and from any one of these forms it can be transformed into any of the others." This notion that all of the energy that has ever existed is still in existence now and is fluidly transforming from one version to another still makes me take pause. It's awe-inspiring. So think for a moment: in what ways are you currently experiencing the Law of Conservation of Energy? (wait) Is your tea transferring heat energy to your hand? Is the chemical energy from your breakfast changing into mechanical energy so you can move through your day? Or maybe potential energy in the hymnal you hold turning into kinetic energy as it drops onto your foot?

It's easy to see kinetic, chemical, mechanical, and thermal energies in action. But what about that other kind of energy? That one described in Chinese as *qi* or by Hindus as *prana* or by Hawaiians as *mana* or by Jewish people as *ruah*? Does that spiritual energy follow the same laws? The circle of life as I teach it in biology involves food chains and ecosystems, and it conjures images of National-Geographic-style lame wildebeests being taken down by lions, but the core of this concept of the circle of life is all about the flow of energy through systems. For some of you, this may seem like quite a leap: to go from quantum mechanics to mystical theorization. But let me try to persuade you. I have some examples that might illustrate my point better than simply presenting the theory to you.

Think of a world leader. How do the people of that nation feel? Frightened? Empowered? Hungry? Cared for? Our leaders have an amazing ability to influence our outlook on life. They can nudge us through their words and actions toward a dim, bleak perspective or a positive, progressive one. The trajectories in which our world leaders choose to direct their energies have profound impacts on the people of their nations and on the world's perception of that country. Bashar al-Assad, for example, has restricted his people from free speech and has actively participated in snuffing out both those opposed to him as well as innocent civilians. The result of the harmful, negative energy he has put into the world is 13.5 million refugees seeking humanitarian aid and a once-beautiful country torn to shreds by war. This situation exemplifies entropy and the decline toward disorder. On the other end of the spectrum, Justin Trudeau, while not unanimously loved (is any world leader?), has served Canada well as PM since 2015. He has focused his energy on repairing relationships with indigenous people and members of the LBGTQ community. He has apologized for systemic discrimination and works hard to right that wrong. The people of Canada do not live in fear that their leader will purposefully harm them. They, instead, make strides in economy and education. Is this because of the energy put forth by their leader? Is the energy that leaders put forth being conserved through their people? Let's look at other examples.

I don't remember my mother. She died before my hippocampus was available for storage. That does not, however, mean that I am unfamiliar with her energy. When I've met her old college friends or talk with my grandparents, aunts, and uncles about her, her light and positive energy flow out of them in their stories about her. They speak about her love and exuberance. The energy that she put into each of those relationships has been conserved in their memories and in their hearts. When I imagine her interactions with those she cared for, I can't help but think of the Second Law of Thermodynamics: heat always moves from hot to cold. Cold exists in as far as it is the lack of heat and it can diminish warmth, but the impact that is always measured is how the cooler body is affected by the warmer. Think of a person in your life who you would describe as warm. How do they affect those with whom they associate? Warmth is contagious. It's catching! So, are we simply the fate of whatever type of energy we receive from others? I'll share just one more example.

My stepmother was vicious. She had a tongue AND a belt for lashing. As grownups, my siblings and I once decided to see what our ACE score might be (ACE is a psychologist's metric to quantify Adverse Childhood Experiences). We took the assessment separately and all came up with the same number: 7. For those of you who don't know, that's bad. Each adverse experience was a direct result of our stepmother's physical and emotional abuse. The energy she used on her children was full of jealous spite, laced with addiction and deep-seated sadness & insecurity. I spoke with my sister recently about that woman and the about of negative energy she expended on us. We came to yet another identical conclusion: she has made us into better stepparents than we ever could have been without her influence. She steeled our resolve to never treat another human the way she treated us. The result of that negative, debilitating energy that she poured onto us is that we found a way to transform that energy. Just like the electric energy flowing from the wall is

transformed into sound energy through this microphone, we transformed her hatred into strong, loving bonds with our blended families.

The circle of life is, at its scientific core, an energy cycle. When a life ends, its energy is transferred out into nature, only to be conserved and drawn into the creation of new life. Physicists call it the First Law of Thermodynamics. Biologists call it ecosystem dynamics. Energy can never be created or destroyed. And cosmic, spiritual energy works the same way. It is always conserved, stored, transferred. And much like electrical energy can become sound, heat energy can become light, negative *qi* can become love, hateful *prana* can become warmth. My argument today is that the circle of life works on both scientific and spiritual/emotional levels. And just like humans have learned to harness physical energy and transform it into productive power, so can we filter spiritual and emotional energies, to take in the negative but *choose* to conserve and transfer the positive.

Is it futile to work against entropy, to battle disorder? Maybe on a cosmic level, but I would like to argue that it is decidedly *not* futile to radiate positive, healing, empowering, loving energy toward one another. It could take the form of an apology like those from Mr. Trudeau, or laughter like that from my mother, or even swallowing a cutting word before it can escape your lips. The energy we have in our bodies has not been created, but we have the power to transform it into something useful and good. The energy we put into the universe can also not be destroyed, but we have the power to *choose* what form it takes as we pass it along to the world, and the people, around us.