

Here, We Control The Dragons

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On 6 August 1945 at exactly 08:15:44, for the first time, a nuclear weapon was detonated over a populated area. The bomb exploded with the explosive power equivalent to 16 kilotons of TNT, 240 meters above the city of Hiroshima, which at the time had a population of about 345,000 people. The resulting heat, shockwave, and firestorm levelled nearly all of the buildings within a mile radius of ground zero and killed about 75,000 people, injuring some 70,000 more. Following this event J. Robert Oppenheimer, the creative technical mind behind the atomic bomb quoted the *Bhagavad Gita* saying, “Now I am become Death, the destroyer of worlds.”¹

Nuclear power fascinates me. Nuclear reactors have been providing electricity to mankind for 61 years, but the weaponization of nuclear power has been instilling fear in mankind for a decade longer than that. The atomic bomb’s formidable ability to destroy life and livelihood is certainly a force to fear; thus, its development was central in the greatest and most dangerous arms race known to man: the Cold War. *Mutually Assured Destruction* (MAD) became the parlance of the Cold War. The mad idea seemed to take hold of the public mind and instill fear, but the fear that “the enemy” might be one step ahead also fueled some of mankind’s greatest inventions and sparked some of the greatest human endeavors in history.² Tensions between the two superpowers, the USSR and the USA, came close to snapping a couple of times, the most notable of which was during the Cuban Missile Crisis when an American U-2 spy plane drifted off course into Soviet airspace during the climax of the contest.³ The fates of millions of lives hung in the balance.

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¹Hijiya, James A. (June 2000). “The *Gita* of Robert Oppenheimer” (PDF). Proceedings of the American Philosophical Society 144 (2). ISSN 0003-049X. Retrieved December 23, 2013.

²A personal favorite of mine is the space race and the moon landings. For generations mankind has looked up in the sky and watched the moon cycle through its phases, but on 20 July 1969 we landed two men on the moon and proved that even the moon wasn’t beyond our reach.

³Even Andrews, “5 Cold War Close Calls,” History, accessed November 10, 2015, <http://www.history.com/news/history-lists/5-cold-war-close-calls>

The more that I study and understand the physics behind nuclear interactions, nuclear reactors, and radiation, the more frustrated I become with the proliferation of misunderstanding and false information.⁴ I wasn't born with knowledge of the quantum world that governs nuclear interactions. Obviously. No one is. But my captivation with the subject has inspired me to dig deeply. At its core, nuclear reactions are a natural process which control the formation of heavy atomic elements. These are essential to the existence of life in what would otherwise be a desolate universe.⁵ As anyone who has taken an introductory, descriptive astronomy class knows, in the core of a star, nuclear fusion takes two smaller atoms and combines them to become one larger atom. While conversely, nuclear fission is what happens when a large, heavy, unstable element like Uranium-235 catches or absorbs an extra neutron, causing the atom to split into two separate, smaller atoms.

When I was in high school I remember learning about the fission process in my physics class and being a little shocked that they would teach pretty much anyone the physics behind a nuclear bomb. Since then I've discovered that all of the necessary information is right there on the internet as well, but trust me when I tell you that the simplified model you'll find on Wikipedia is not going to be enough to build a nuclear bomb.⁶ Nuclear concepts are simple really, two things combine into one, or one thing rips apart into two, it's the math that is going to slow you down. Though in both cases, the energy that is released is modeled by $E = mc^2$.

If you grew up in the 90s like I did, then it's possible that like me, you also only know the conflict that nuclear power has caused through the eyes of history books and the news stories that have kept us informed on the current issues.⁷ Generally, it almost feels as though nuclear threats have become a thing of the past, so much so that on occasion we talk and

⁴The voices of scientists often seem to struggle to curb the fear that is perpetuated through the media, and the feelings I have towards this aren't only in my frustration with the false ideas about nuclear energy. The entire immunization debate is something that never should have happened. One scientist produced false data and lied about the results, and his selfish desire to make more money off of a new vaccination that he had developed has led to the return of small pox, measles, and whooping cough in America. No one can actually control the actions of individuals, and as a result misinformation can spread and cause damage that is difficult to repair.

⁵To an astronomer anything heavier than Helium is considered "heavy." During the Big Bang only Hydrogen and Helium were made (with trace quantities of Lithium), but in order for life on Earth to exist, there needed to be Carbon, Oxygen, Nitrogen, and other "heavy" elements. Elements lighter than Iron are formed during a star's main cycle through the process of fusion. Elements heavier than Iron are formed during any of the types of supernova. Elements heavier than Uranium are not naturally found on Earth due to the instability of the heavy nuclei. These massive elements are likely formed during supernova, but due to the length of time it took for life to form on the Earth (about 4.5 billion years), those elements heavier than Uranium have all decayed.

⁶I study physics. I've spent a few years now focusing on the necessary mathematics and physics required to understand the quantum world. Even after a couple years of university math, a semester on modern physics, and another semester dedicated solely to quantum mechanics, there is still no way that I actually understand all of the physics behind a fission reaction, let alone the feat of engineering it is to control one. My experience has shown me that it would take a truly gifted person to understand how to create something nuclear and dangerous only using the internet as their guide — not to mention how impossible it is to acquire the necessary equipment and materials to carry it out.

⁷There are the seemingly yearly incidents with North Korea, which I'll address in more detail later, and recently the notable nuclear talks and agreements that the US made with Iran, which I won't elaborate on here.

joke about how the older generation had to practice the “duck and cover” drills. Duck and cover? Really? Maybe in a world gripped with fear the right thing to do is to not tell the truth. Hiding under your desk is not going to prevent much of anything in a nuclear blast, but if you believe it will help, then maybe clinging to hope is the only thing that matters.

Peter Watkins, wrote, directed, and produced a drama-documentary called *The War Game*, graphically depicting a hypothetical, limited, nuclear strike on the United Kingdom.⁸ Originally planned for release in October 1965, the BBC banned it from being publicly aired for 20 years for factors labelled as “too horrifying,” “institutional,” and “cultural.”⁹ For a 1965 film, I didn’t expect it could be too horrifying, but oh how I was wrong. As I watched this film there were moments where I physically felt sick at the sight of both the physical and mental human suffering. After some gruesome depictions of mass death, mass suffering, and mass graves, the following poem scrolled up across the screen:

Oh where are you coming from, Soldier, gaunt Soldier,
With weapons beyond any reach of my mind,
With weapons so deadly the world must grow older,
And die in its tracks, if it does not turn kind.¹⁰

As depicted in the film, months after a hypothetical, limited, nuclear attack, hunger riots would likely break out due to dwindling supplies of food. The food would need to be guarded and would perhaps be given as reward to those who honoured and upheld the law. Desperate people would likely riot and even murder volunteer guards in a struggle to survive. Having lost so much of the control and feelings of security that people possess over their lives it’s likely that people would give up and become apathetic and lethargic. Could it be possible to reach a point where the living might envy the dead?

When the film posed that question, I was struck by that terrible but possible idea. What sort of thoughts would hindsight bring to mind? Upon reflection, would you rather have stayed out in the open after hearing the sirens, which might give you at most three minutes of warning? This suddenly isn’t something to joke about anymore. What kind of suffering would cause normal, everyday people to desire death?¹¹

After watching the film, I began to more fully understand why so much fear has surrounded nuclear power. I was not there in the years following World War II, so I cannot fully understand the depth of human suffering that was experienced in Hiroshima and Nagasaki, but I can catch a glimpse into the lives of the people who lived then by engaging in their art. Artists, like Peter Watkins, possess the power to control their medium, and by capturing the moment they are able to transcend time and speak to those from a different time and place.

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⁸Peter Watkins, *The War Game*. Directed/Performed by Peter Watkins, Micheal Aspel, Peter Graham, and Kathy Staff. 1965. BBC. Film

⁹Chapman, James. “The BBC and the Censorship of *The War Game*”, *Journal of Contemporary History*, Vol. 41 No. 1, page 84.

¹⁰Peter Watkins, *The War Game*. Directed/Performed by Peter Watkins, Micheal Aspel, Peter Graham, and Kathy Staff. 1965. BBC. Film

¹¹Ibid.

I feel drawn to the usefulness of nuclear energy but I understand that human relationships are not always, if ever, altruistic. Nuclear reactions create massive amounts of energy, which, if harnessed, would greatly decrease our planet's dependency on fossil fuels. On the other hand, if this energy were harnessed, it could be used to end thousands of lives. Such ends depend upon how this power is controlled. We live in a world of heroes and villains, a world of eidetic moments and wish-we-could-forget scenes, a world of art, and a world of science. This brings me back to 6 August 1945. For me, this date presses deeply on my mind because of how the events of that day have shaped the world's perspective of war and because of my struggle to comprehend the depth of pain associated with the loss of human life. It fills me with awe, and awe is truly the most accurate word to describe how I feel. The Oxford English Dictionary defines awe as "the feeling of solemn and reverential wonder, tinged with latent fear, inspired by what is terribly sublime and majestic in nature."¹² Like a streak of lightening followed by thunder, I fear the lightening, but marvel at the majesty of the thunder. I marvel at the power contained within the atomic nucleus, but fear what it is capable of.

Both before and since the Manhattan Project, the cleverest minds in science and politics have come together to control and subdue the atom, like valiant knights challenging to tame a ferocious fire breathing dragon, awoken from his eons of slumber.¹³ It is as though upon discovering the mightiest dragon of all, mankind has called him forth and challenged him face to face. Like Beowulf, mankind has boasted its strength and challenged the greatest power in all the world. As Beowulf, we cry out in a ringing voice:

"Come out, O most foul fiend? Come out, I say, arch-dragon, and pit your vaunted strength against my strength, which is the greatest known in all this cold Northland!"...

For a moment there was a death-like stillness in the night. No sound came from the cave, and no steamy breath, and no dull glare of fire. Then with sudden roaring that caused the night to splinter and the earth to quiver in horrified response, the lordliest dragon in all the world rushed from its lair.¹⁴

It seems to me that mankind's attempt to control nuclear power is analogous to this mighty challenge. Have we become so confident that we have begun boasting of our strength and calling out to fight the "lordliest dragon in all the world"? Well that's what we did, and I hope the world never forgets the scar the beast left on Japan when he awoke. Yet in spite of this scar, mankind continues to fight to subdue the dragon and use the dragon's hoard for his own purposes. It's a dangerous struggle and Beowulf's death by the dragon following his challenge could be analogous to mankind's fate if control over the dragon is ever lost. Also, the king's desire to win the dragon's horde for his people is slightly ironic, as in his dying moments he clutches to the decaying, rusting, material objects he liberated. This ironic sense of triumph is akin to the great usefulness of nuclear energy, but the ever persisting risk of radiation leaks.

¹²"Awe," *Oxford English Dictionary*, accessed November 10, 2015, <http://www.oed.com/view/Entry/13911?rskey=kL4K9A&result=1&isAdvanced=false#eid>

¹³Wain Fimeri, *Uranium: Twisting the Dragon's Tail*. Directed/Performed by Wain Fimeri, Steve Westh, and Derek Muller. 2015. PBS. TV Film.

¹⁴Strafford Riggs, *The Story of Beowulf*. (London : Abela Pub., 2010), 84-5

It seems our nature as humans to learn through the experience of playing with fire. We have this self-confidence that creates an illusion of control, right up until we burn ourselves. So if we've challenged to subdue the most powerful force on Earth, and mankind has revealed itself to be less than altruistic most of the time, then how much control do we actually have and where do we lose control? With a set of related concerns: Is the treasure hoard worth the risk of receiving fatal blows as we attempt to subdue the nuclear dragon? Do everyday people like you and I actually have any real control over such a massive issue?

For the most part, large issues are left to those we elect into government to sort out. We the people are in control of who represents us on the world stage...right? Well, let me try to set the scene: The leaders of the world have expended great amounts of effort to control the proliferation of nuclear arms and nuclear technology, understanding that the consequences of apathy could be catastrophic. The Non-proliferation Treaty (NPT), entered into force in 1970, was enacted "to make every effort to avert the danger of [nuclear] war... believing that the proliferation of nuclear weapons would seriously enhance the danger of nuclear war."¹⁵ Thus, losing control of which hands have access to the use of nuclear power could be the beginning of the reign of the cockroaches.¹⁶ Though this then raises another question: why should some people be allowed to benefit from nuclear power but not others?

On 8 December 1953, 11 years before the initialization of the NPT, US President Dwight D. Eisenhower gave a landmark speech in front of the United Nations General Assembly suggesting the formation of an International Atomic Energy Agency (IAEA). During his speech, he addressed the concern of maintaining control over the proliferation of nuclear technology, the need for the IAEA to help "provide abundant electrical energy in the power-starved areas of the world," and the desire to mobilize experts in applying "atomic energy to the needs of agriculture, medicine, and other peaceful activities."¹⁷

Clearly, the discovery of nuclear power has the potential to relieve suffering, and improve quality of life, if controlled correctly, but the NPT and IAEA make the use of the technology a pretty exclusive club. Four years following President Eisenhower's address, the IAEA was founded in 1957 and since then the organization has been the international authoritative word on nuclear power regulations. The 1956 IAEA Statute was formed from the ideas presented by President Eisenhower, and was unanimously agreed to by 81 nations.¹⁸ Wait. There were certainly more than 81 nations in the world at the time, so where were the rest of the nations and did they get a say in the matter? The short answer is they weren't a part of the United Nations, and though the UN has not lived up to its promised potential, it is required to be a part of the club in order to vote. At the time the IAEA Statute was signed, there were a little over 100 nations in the world. To date there are 166 member states of the IAEA, with 29 non-members states. Of the 29, five are waiting for approval to be members, 23 are not members, and one was a former member — North Korea.

¹⁵United Nations, "Non-proliferation Treaty," United Nations, accessed November 10, 2015, <http://www.un.org/disarmament/WMD/Nuclear/NPTtext.shtml>

¹⁶MythBusters actually did an episode on how likely it would be that cockroaches could survive a nuclear fallout and determined that it would be probable, though the fruit fly was found to be the most resilient to lethal doses of ionizing radiation.

¹⁷Dwight Eisenhower, "Atoms for Peace," Voices of Democracy, accessed November 10, 2015, <http://voicesofdemocracy.umd.edu/eisenhower-atoms-for-peace-speech-text/>

¹⁸International Atomic Energy Agency, "History, Revisiting the Past," International Atomic Energy Agency, accessed November 10, 2015, <https://www.iaea.org/about/history>

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Before we go any further, let's acknowledge that international politics are difficult and extremely complex. Mankind's long history of conflict is indicative of our struggle to reconcile differences. The notion of what we can control and what we can't really shows itself in politics. Treaties and agencies like those discussed above all look great on paper, but treaties and laws don't actually control the behavior of individuals. Consequences for breaking the law do suppress the behaviours the laws are intended to subdue, but it is difficult to enforce laws on a global scale. So what happens if a country decides that they don't want to follow the same rules that everyone else has agreed to?

I've played many games of basketball where the players don't respect the rules; even I have taken advantage of a referee's moment of inattention to get away with some things the rules don't allow. I was once down by the basket surrounded by about six or seven other players, when the ball was fumbled and I grabbed it in between my knees. I don't know what came over me, but I decided that the best thing to do next was to jump out of the crowd of people, still holding onto the ball with my legs. So I did. I then reached down, took the ball, and made a basket, which they counted. The other team returned the favor and I became the victim of an unfair elbow that resulted in blood gushing from my nose for a few minutes while the game continued on without me. Yet basketball games and nose bleeds are far too simple of an analogy to accurately convey the weight of consequences associated with intolerable behavior on the nuclear court.

Now I'm not an expert on the complicated relationship that North Korea has with the rest of the world, but let me do my best to summarize a part of what I do know and how their relationship reveals what we can control, what we can't control, and how much control individuals have over large scale issues. North Korea is well known as a player on the international nuclear court that doesn't seem to follow the rules. There is a long history of dialogue between North Korea and the UN (particularly through the US and China) in an attempt to help North Korea become a self-sufficient entity and a contributor to the world stage, but negotiations have been tremendously difficult for both sides.¹⁹ North Korea initially agreed to the ideals of the NPT on 12 December 1985, but never came into full compliance. The UN often used economic strategies such as sanctions or offering aid in attempts to try and convince North Korea to comply. Conversely, North Korea would threaten to leave the NPT, or would refuse to allow the IAEA to inspect their nuclear reactor locations on an ad hoc basis. In this way, they were able to maintain some level of control over the situation.²⁰ Finally, on 10 April 2004 North Korea withdrew from the NPT, subsequently removing themselves from IAEA jurisdiction and control.

The point is that strategic negotiations with North Korea were difficult and in the end didn't work.²¹ Since the everyday person is not directly involved with foreign affairs or international diplomacy, it may seem as though individuals not directly involved in politics

¹⁹Rudolf Avenhaus, Victor Kremenjuk, and Gunnar Sjöstedt, *Containing the Atom: International Negotiations on Nuclear Security and Safety* (Lanham, MD: Lexington Books, 2002), 211-238.

²⁰Ibid., 225.

²¹On 9 October 2006, North Korea reported a successful nuclear test, with a second on 25 May 2009, and a third on 12 February 2013. The interesting thing to note is the different reaction that the West had when compared to the nuclear tests performed by the USSR. There were no duck and cover drills and the public didn't seem overly concerned. However, the South Korean public was, and is, more immediately concerned.

play no part in this game. Yet this is not the case. People want the stability that comes from relinquishing some of their control to a government or higher power, but they do not want this government or higher power to exercise too much control over them. Thus, individuals can then become an uncontrollable variable in the interactions between nations. For example, though not strictly an individual, Sony Pictures produced a film entitled *The Interview* (2014)²² which quickly became controversial, disrupting relations between North Korea and the West in ways that may not have been immediately obvious to the producers.²³ I'm not saying that we should control what people say, but what I am saying is that while Sony as an entity has not been directly involved with US - North Korean relationships, their product, *The Interview*, had a negative influence on that relationship, damaging years of professional diplomacy.

The more important issue in all of this is that the entire notion of what we can control and what we can't control is more than just complex, it can be uncomfortable. At any rate, it's uncomfortable to me. I believe that the most complex and uncomfortable issue regarding control that persists in our world today is terrorism. If I'm not an expert on North Korea, than I'm even less of an expert on terrorism, but I personally know more people who have been immediately affected by terrorism than the high-level nuclear talks with North Korea.²⁴ North Korea is a recognized nation which makes negotiations and sanctions more unambiguous (even if they're not simple or straightforward); thus, there is some greater measure of control that exists regarding unruly behavior. Even so, as the evidence shows, in spite of all of the treaties, all of the negotiations, and all of the diplomacy, North Korea still removed itself from UN jurisdiction and went ahead to successfully develop nuclear weapons. This reveals some of the UN's weaknesses and demonstrates the UN's inability to respond well to global crises.²⁵

With the "war on terror" being so prevalent in the world today, how do we handle the great levels of uncertainty? Do we allow the fear of what we can't control dictate our lives? Do we avoid thinking about exactly how much danger we could be in because of how uncomfortable the thought is? In this way we control our own little spheres of influence and go on hoping that someone else with more power and wisdom will solve these complex and difficult issues. Terrorism has magnified the social-political issues that are difficult to control and it has made them personal.

²²Evan Goldberg and Seth Rogan. *The Interview*. Directed/Performed by Evan Goldberg, Seth Rogan, James Franco, and Seth Rogan. 2014. Sony Pictures. Film.

²³In case you don't remember what the film was about and why it was controversial, here is the synopsis from IMDB: "Dave Skylark and producer Aaron Rapoport run the celebrity tabloid show 'Skylark Tonight.' When they land an interview with a surprise fan, North Korean dictator Kim Jong-un, they are recruited by the CIA to turn their trip to Pyongyang into an assassination mission."

²⁴Every single Muslim that I personally know are the first to be most immediately affected by the current terrorism in the world. Could you imagine if you were publicly persecuted because of persistent misinformation about your religion? Not only that, but what if your religion wasn't even associated with the stereotyped terrorists, but because of your sacred clothing and skin color millions would be visibly concerned by your presence? Many Sikhs receive racial prejudice and are assumed to be Muslim (and by illogical implication a terrorist) because of their turbans and skin color, when no practitioner of either faith would allow that kind of hate and anger to escalate. I also know others who have been affected by terrorist attacks like 9/11, and the London train bombings in 2005.

²⁵A whole nother issue altogether.

In the popular song by Neva, *99 Luftballons* (1985), a scene is described where an carefree act is met with misunderstanding and catastrophic consequences.²⁶ In the English translation, the song describes two people that buy 99 red balloons and excitedly release them into the sky one summer's day. The story relates how there are bugs in the software back on a military base, creating panic when the software signals that "something's out there." The panic causes a red alert, over-reaction leading to a decision made by a group of important people (including the president). They call the troops out and the super high-tech fighters. The song finishes with this last stanza:

99 dreams I have had
 In every one a red balloon
 It's all over and I'm standin' pretty
 In the dust that was a city
 If I could find a souvenir
 Just to prove the world was here...
 And here it is, a red balloon
 I think of you and let it go.²⁷

This song is particularly interesting to me because growing up, I never realized that it was a song about a nuclear attack destroying a city. That might seem odd to someone who remembers when this song first came out, but to me the song was just another classic pop song. It has a catchy tune and a predicable "99... something, something" that you could pretend to sing to, but I never took the effort to read the lyrics.²⁸ Thus, I was surprised when I discovered the message it conveyed. The last stanza was especially potent to me because it conveyed the devastation and human suffering involved with losing control of a situation and allowing adrenaline to dictate your actions (much like my experience on the basketball court). Altruism doesn't win you basketball games, but it may have prevented me from receiving that nose bleed. I feel that this song shows that large scale things can become very personal²⁹ and that our individual actions can have some sort of influence over large scale events. Similar to *The Interview* and the innocent release of 99 red balloons into the air, our actions can have far-reaching effects. It's difficult to know though if our actions had a direct influence on events, or if there were any "bugs in the software" that could cause someone to misinterpret what we do.

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²⁶Neva, *99 Luftballons*, AZ Lyrics, accessed November 10, 2015, <http://www.azlyrics.com/lyrics/goldfinger/99redballoons.html>

²⁷Ibid.

²⁸And to be honest, I'm really bad at making out what the specific lyrics of songs are just by listening.

²⁹Social media has a real and powerful influence over the current state of control today. There was an article by Rukmini Callimachi in *The New York Times* entitled, "ISIS and the Lonely American." The article states that, "Through January this year [2015], at least 100 Americans were thought to have traveled to join jihadists in Syria and Iraq." The article is about an ISIS member trying to recruit a twenty-something, young, American woman by using social media. There are also many other articles reporting young people from Western Cultures being recruited to join ISIS through the use of social media platforms such as Facebook, Twitter, and others.

There simply are things that we can't control, and sometimes those things fill us with fear. Conversely, there are some things that we do control, and control very well, and those things seem to provide us with a sense of confidence. Our subjugation over the nuclear dragon reveals what we can control, what we can't, and what we fear, but is the treasure hoard worth the risk?

What does the dragon look like when it has been tamed? All of the nuclear reactors today are nuclear *fission* reactors. There are a few prototype nuclear *fusion* reactors, but the design has yet to be mastered. The most common type of fission reactor is referred to as a Light Water Reactor (LWR). The water used in a LWR has a two-fold purpose: firstly it is used to stabilize the reaction, and secondly, the water absorbs the heat that is used to power turbines and produce electrical power. A nuclear reactor is constantly undergoing a chain reaction of nuclear fission, which is stabilized using stray neutrons released in the fission reaction. To control the reaction and to slow the neutrons to a *thermal* velocity, the core is submersed in water.³⁰ The hydrogen molecules in the water absorb the energy of the neutrons which heats up the water. This interaction is like colliding two ping-pong balls together (compared to a ping-pong ball and a bowling ball).³¹ These continuous neutron-hydrogen collisions heats the water into the steam that drives the electrical generators.

The ingenuity of the design of nuclear reactors is that they self-regulate. The reactors physically *cannot* blow.³² And then just to make sure, every reactor is equipped with stabilizing control rods. Thus, when something extremely terrible happens the control rods are immediately shoved into the core, stopping the chain reaction almost instantaneously. Hence, we have domesticated a dragon.

Essentially, mankind has valiantly been able to control nuclear power and harness it, reducing our dependence on fossil fuels. Advances in physics and engineering have led to mankind's ability to meticulously control nuclear reactions. The scientific method has lead us to an understanding of our universe on both a microscopic and macroscopic level. From this we have been able to control the elements and create things out of our wildest imaginations, like the smart phone. Creations like smart phones and nuclear reactors inflate our confidence and perception of the amount of control that we have. Like the younger Beowulf, we are seemingly invincible, but time is no respecter of persons, old age and weakness come to all. Our control over the microscopic world seems unquestionable, but our control over the macroscopic world is often held in check.³³

³⁰Nuclear Energy Institute, "How Nuclear Reactors Work," Nuclear Energy Institute, accessed November 10, 2015, <http://www.nei.org/Knowledge-Center/How-Nuclear-Reactors-Work>

³¹The mass of a neutron and Hydrogen are pretty much the same and because of the nearly equal masses of the two particles, the momentum of one can be transferred entirely to the other. However, "heavy" elements are like the bowling balls. When the ping-pong ball collides with a bowling ball, there is almost no momentum exchange. This is because of the massive amount of inertia that a bowling ball has compared to a ping-pong ball.

³²I actually didn't know before more thorough research that a nuclear reactor physically can't blow the same way a nuclear bomb does. This new knowledge removed many fears that I had gathered over the years. However, it is important to note that while a nuclear plant will not explode like a nuclear bomb, there is still a risk of a radiation leak. This is the irony in taming the deadly dragon in order to use his gold: the treasure is precious, but in a harmful state of decay. In particular, it is ionizing radiation that is dangerous *in lethal doses*.

³³I actually find it strangely contradictory to write about how uncontrollable the macroscopic world is

While the force of a nuclear bomb gives us the power to control the fate of millions of lives, it is merely a natural power that has been subjugated through human engineering. Contrast this to how over 250,000 people died³⁴ in Haiti during the January 2010, 7.0 earthquake, more than the combined total of those who died and were injured in both the Hiroshima and Nagasaki bombings. I again struggle to comprehend the depth of pain associated with the large scale loss of human life, but mankind was not responsible for these deaths. These were not the atomic bombings of 1945, nor was it a terrorist attack like 9/11, rather it was a natural occurrence we had no control over. But nature will always exploit our lack of control over the macroscopic world.

The world seemed to hold its breath when Japan was struck by an 9.0 earthquake in March 2011. I immediately reflected on the devastation that Haiti had experienced only 14 months earlier, but after learning that one of the Fukushima nuclear reactors had also melted down I began picturing the monster child of a Haiti-Chernobyl³⁵ catastrophe. I then began to question exactly how the nuclear reactor had melted down. Didn't Chernobyl teach the world how eager the dragon is to strike at the unprepared? Didn't we learn our lesson the first time? How did we lose control again?

After the earthquake there was some instability in the nuclear reaction and the Fukushima reactor was immediately shut down. Everything was in order and doing well until the tsunami came. While a reactor can be immediately shut down in an emergency, there is still some heat produced by the core called *decay heat*. To remove this heat from the core, and prevent a meltdown, the water surrounding the core is cycled through to allow continuous cooling. When the tsunami hit, it took out the back-up generators that were pumping the water and caused the core to heat up and melt down, releasing the radiation that would have otherwise remain contained.³⁶

Despite all of the precautions, the system wasn't ready for such a powerful earthquake and tsunami. Initially everything was under our control, but the unpredictable tsunami came and eliminated what little control remained. Earthquakes, tsunamis, hurricanes, tornadoes, and volcanic eruptions are all entirely beyond our ability to control. There may be some form of predictability, but no real sense of control. Is the treasure worth the risk then?

Like anything else, ionizing radiation is only deadly in lethal doses. Even water has a lethal dose, though the scary thing about ionizing radiation is *how* it will kill you. This *how* is part of the reason why the living might begin to envy the dead after a nuclear strike. Radiation poisoning could cause normal, everyday humans to desire death. It's a really miserable thing. Essentially, it makes it so that there is an excessive amount of cancer in

in comparison to the microscopic world, especially when I consider the probabilistic nature of quantum mechanics and the deterministic nature of Newtonian mechanics.

³⁴I understand that large numbers can be difficult to actually comprehend sometimes, so think about 250,000 people being a little under half of the population of Wyoming, or about four times the capacity of the LaVell Edwards Stadium.

³⁵The Chernobyl exclusion zone covers approximately 1,000 square miles and displaced about 91,200 people in 1986. It stands today as the worst ionizing radiation leak in history.

³⁶Chernobyl's meltdown was much worse and was essentially caused by the operators turning off all of the safeties and running a test to see what the reactor would do. In the middle of this test, with all of the safeties still off, there was a midnight crew change, and the new crew was unaware of the ongoing test and lack of safety. Thus, when the test went awry an hour into their shift, they were completely unprepared for the situation.

your body. Your cells lose control over how they split, reproducing incorrectly over and over again with nothing to slow them down. You basically die from the inside out. Not only that, but the radioactive isotopes that are released into the environment can make some places inhabitable for 30 years, 100 years, 100,000 years, and in some cases over 4.5 billion years.

So is it worth it? The issue is whether or not you feel secure in the degree to which we have to subdue the dragon. As long as he is contained, we are safe right? In truth, we more or less have tamed the atom (nuclear energy currently provides 11% of the world's electricity), but don't let the dragon get out because he's hungry.

* * *

Perhaps the reason so many people fear nuclear energy is because while there is no physical way for a nuclear reactor to explode like a bomb, there is no prevention in its design to prevent the removal of fuel from the core for the purpose of weaponization, and there is always the residual possibility of a radiation leak. It isn't exactly the nuclear reaction itself that we fear, rather it is the people who control those nuclear reactions, and the people who control the lethal doses of ionizing radiation. So how do we control the people who control the atoms? Should we? Should one nation, or group of nations, have the power to decide what another nation, or group of nations, should or should not do? Constraining people in an attempt to make them change them usually doesn't work out very well.³⁷ Other people are exceptionally difficult to control, and whether or not you believe in free will, this fact remains true.

Still, we control the science. Mankind has become exceptionally good at manipulating the world around him to suit his needs. We also have the power to more-or-less control what goes on in our own personal lives. Though, in spite of how well we micromanage our own personal lives, external forces still possess the power to change us. These external forces could be our homework, jobs, families, and other obligations we agree to,³⁸ and yet, there are even greater external forces that can influence and try to control our lives, like terrorism or natural disasters.

Even so, I believe that the question this really comes down to is how are *you* going to continue to view the world? Are you going to continue to live your life believing that because you experience no immediate threat or conflict that things are under control? The next time you go to a concert in Paris are you going to have this gnawing sense in the back of your mind that you might not make it safely home? I'm not trying to start a scare or spread any false information — I just wonder if we've become apathetic to our lack of control because our day-to-day lives don't show any evidence that we might not be in control. It may be naive, but I much prefer to live my life believing that everything is going to work out and that I have the power to decide what to do and where to go. It keeps me happy, but what do you think?

³⁷Look at what happened with North Korea. Also, consider the crisis in the Middle East. A few scholars claim that much of the problems that have come out of the Middle East in the past two decades have come because of the attempts to control certain groups.

³⁸I'm not saying that we do these things grudgingly, but rather that when we submit to committing to do something, sometimes those commitments become bigger than we intended. Thus, in a way we lose how much control we have over our lives because someone, or something else is dictating what we should do.

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