

HORMESIS

by

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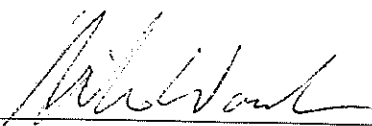
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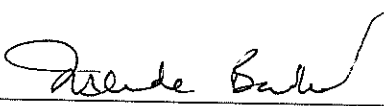
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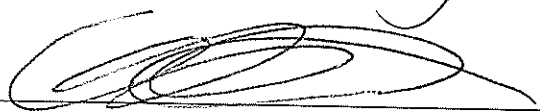
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Hormesis

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*Hormesis* is an installation created by Megan Gafford that explores the way art and science can implicate each other in the search for the sublime. The piece includes a cloud chamber style subatomic particle detector and a film of the radiation made visible in that machine. This paper describes the philosophical, art historical, and sociopolitical concerns that informed *Hormesis*.



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## CHAPTER 1

### HORMESIS

Hormesis is the hypothesis that low doses of radiation are healthy and perhaps even necessary for life. The idea was popular at the turn of the twentieth century, when pharmacies advertised radioactive tablets, bath salts, inhalants, injections, suppositories... even chocolate candies and toothpastes. These were marketed to cure everything from rheumatism to baldness.<sup>1</sup> As humanity continued to toy with the subatomic word, hormesis became a controversial theory, and some scientists have thought that even small amounts of radiation cause serious genetic harm.<sup>2</sup> Today, researchers are still investigating the question of what low doses of radiation do.

In the wake of WWII and the Cold War, radiation is understandably terrifying, and the limits of human understanding enhance that fear. Even without the threat of nuclear war, the phenomenon is mystifying in the way it invisibly impacts us. Everyone is constantly exposed to cosmic background radiation from outer space, especially here in Colorado where the high altitude and thinner atmosphere offer less protection. Further exposure occurs at the even higher altitudes inside airplanes, in hot springs warmed by radon gas, and in the traces of tobacco inhaled with cigarette smoke. The scientific consensus is that these low doses are not only inevitable but comparatively un concerning in relation to more fully understood health risks like industrial exhaust, heart failure, or car accidents; yet, these more pressing dangers do not elicit the same kind of aversion.

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<sup>1</sup> Spencer R. Weart, *The Rise of Nuclear Fear*, p30

<sup>2</sup> Weart, p117-8 and 186-7



My installation, named *Hormesis*, creates an opportunity to see a normally invisible part of the natural world through a diptych structure that includes a particle detector and a video projection. It exposes you to gamma radiation emitted from uranium ore, which is encased in a glass chamber and engulfed in an alcohol cloud. As the uranium decays, subatomic particles flying off of it create condensation trails similar to what airplanes leave behind in the atmosphere. These particle trails are the closest you can come to seeing a subatomic particle with your naked eye.

Cloud chambers were created by Charles Thomson Rees Wilson, who won the Nobel Prize in physics for his invention in 1927.<sup>3</sup> Physicists used this style of particle detector until the 1950s to discover subatomic particles like positrons and the cosmic background radiation.<sup>4</sup> It works via a temperature gradient, with pure isopropanol at room temperature in a reservoir at the top of the chamber evaporating and falling to a frigid plate at the bottom, which forces the vapor to supersaturate into a cloud. Radioactivity travelling through the air ionizes the cloud so that it condenses like a nucleus around the particles. Without a radioactive source, cosmic rays will periodically ionize in the chamber, but the uranium sample I use reveals far more activity.



Wilson's original cloud chamber on view at the Museum at the Cavendish Laboratory in Cambridge, Massachusetts<sup>5</sup>

<sup>3</sup> Nobel Prize in Physics, [http://www.nobelprize.org/nobel\\_prizes/physics/laureates/1927/wilson-facts.html](http://www.nobelprize.org/nobel_prizes/physics/laureates/1927/wilson-facts.html)

<sup>4</sup> Nobel Prize in Physics, [http://www.nobelprize.org/nobel\\_prizes/physics/laureates/1936/index.html](http://www.nobelprize.org/nobel_prizes/physics/laureates/1936/index.html)

<sup>5</sup> The Museum at the Cavendish Laboratory, <http://www-outreach.phy.cam.ac.uk/camphy/museum/area2/cabinet1.htm>



All of the uranium on earth was created at least six billion years ago in supernovae explosions.<sup>6</sup> What is more, every atom of every element was created in the nuclear reactions within stars or, like uranium and other heavy elements, when those stars exploded. This means that not only uranium, but every bit of matter in our bodies was once part of a star -- in the infamous words of Carl Sagan, “We are star stuff.”<sup>7</sup> Nuclear radiation fueled the stars that became life on earth, it fuels our sun that allows this life to thrive, and it emanates from the uranium ore in my cloud chamber. Radiation causes growth and decay, and it symbolizes the seemingly infinite nature of the cosmos.

Standing in the installation, you are literally observing the movement of the subatomic world. But this opportunity comes with a risk: viewers are exposed to actual uranium ore, creating the conditions for fear. But this fear is balanced with the poetic experience of cinema, which insists this radioactivity is beautiful. The film was shot through a macro lens and projected onto a wall at mural-scale, transforming the tiny trails into an immersive, moving-image wherein the subatomic world is revealed as a graceful dance, an uncanny landscape, and a peculiarity of the weather. While the detector permits us the nearest thing to seeing a subatomic particle with the naked eye, the film allows a more intimate observation of that visualization.

Film is an ideal medium for making an artistic observation of radioactivity, in part, because the phenomenon embodies the ideal of *photogénie*. Filmmaker and theorist Jean Epstein, an influential artist associated with the French Impressionist Cinema of the 1920s<sup>8</sup>, asserted that, “any aspect not enhanced by filmic reproduction is not photogenic, plays no part in

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<sup>6</sup> Cosmic Origins of Uranium, <http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/the-cosmic-origins-of-uranium.aspx>

<sup>7</sup> Carl Sagan in a clip from *Cosmos*, <https://www.youtube.com/watch?v=tLPkpBN6bEI>

<sup>8</sup> A nebulous movement also known as “the first avant-garde” in film



the art of cinema.”<sup>9</sup> He stipulates that, “only mobile and personal aspects of things, beings, and souls may be photogenic; that is, acquire a higher moral value through filmic reproduction. This mobility should be understood only in the widest sense, implying all directions perceptible to the mind.”<sup>10</sup> Epstein was writing during cinema’s infancy, and his prerogative was the modernist goal of defining an art form by its own terms. For him, *photogénie* was the essence of cinema, and it needed a theoretical framework. He continues:

I have never really understood why the notion of a fourth dimension has been enveloped in such mystery. It very obviously exists; it is time. The mind travels in time, just as it does in space. But whereas in space we imagine three directions at right angles to each other, in time we can conceive only one: the past-future vector.... Photogenic mobility is a mobility in this space-time system, a mobility in both space and time. We can therefore say that the photogenic aspect of an object is a consequence of its variations in space-time.... [If] a drawing which ignores the third spatial dimension in its perspective is a bad drawing, I must now add that cinema composed without taking the temporal perspective into account is not cinematic.<sup>11</sup>

I am unsure of what Epstein means about the morality of filmic reproduction, but I think he is insisting that cinema should not be redundant. He seems to be saying that the relationship humanity has to its environment already has moral implications, and filming those relationships is pointless unless the film intensifies them. Moreover, because film is a sequential art this intensification must involve time. If the relationship between humanity and a thing can be enhanced with a still image, Epstein claims it should not be filmed. This theoretical framework points to cinema as a perfect vessel for creating a more intimate experience with the phenomena of radioactive decay.

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<sup>9</sup> Jean Epstein, *On Certain Characteristics of Photogénie*, p312

<sup>10</sup> Epstein, p314-5

<sup>11</sup> Epstein, p315





A still image cannot make radioactivity “acquire a higher moral value,” as Epstein demands. The temporal perspective is critical for imaging that phenomenon. The condensation tracks inside my cloud chamber are the closest a person may come to witnessing subatomic particles with the naked eye. However, the chamber does not make the particles themselves visible but their paths through space and time. So viewers are literally watching the movement of the subatomic world.

My attraction to Epstein’s theory is moored to his statement that, “If we wish to understand how an animal, a plant, or a stone can inspire respect, fear, or horror, those three most sacred sentiments, I think we must watch them on the screen, living their mysterious, silent lives, alien to the human sensibility.”<sup>12</sup> Here he describes an important aspect of the emotional response I want to elicit from my viewers, with an example that seems eerily specific to my purposes. I am trying to create a paradoxical experience of feeling simultaneously attracted and repulsed by presenting a horrifying substance in a beautiful way. My visualization of radioactive decay ironically appears to grow and move like a living thing, as if the stone is living a silent life in some alien environment. The film in *Hormesis* allows a deeper understanding of the particle detector through magnification and montage.

My film is influenced by poetic cinema, as exemplified by Nathaniel Dorsky, one of the most highly regarded experimental filmmakers alive today.<sup>13</sup> His work was aptly described by Richard Suchenski, who helped organized a screening of his work at Yale, when he said an important aspect of Dorsky’s films is how objects are, “decontextualized and sometimes unmoored from their surroundings, allowing connections to develop which resonate not only between shots but also across the films as a whole, encouraging more active forms of

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<sup>12</sup> Epstein, p314

<sup>13</sup> I had the pleasure of becoming friends with Nick when he came to CU Boulder as a visiting filmmaker in 2015



awareness.”<sup>14</sup> Skilled lighting, non-traditional camera focus, and carefully edited montage characterize Dorsky’s filmmaking. His work is projected silently to achieve delicacy and intimacy. Dorsky tells us:

In film, there are two ways of including human beings. One is depicting them. Another is to create a film form which, in itself, has all the qualities of being human: tenderness, observation, fear, curiosity, the sense of stepping into the world, sudden murky disruptions and undercurrents, expansion, pulling back, contraction, relaxation, sublime revelation. In my work, the screen is transformed into a "speaking character", and the images function as pure energy rather than acting as secondary symbol or as a source for information or storytelling. I put shots together to create a revelation of wisdom through delicate surprise. The montage does not lead to verbal understanding, but is actual and present. The narrative is that which takes place between the viewer and the screen. Silence allows these delicate articulations of vision which are simultaneously poetic and sculptural to be fully experienced.



Nathaniel Dorsky, still from *Aubade*, 2010, 16mm film

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<sup>14</sup> Yale News, *Devoted to Devotional*, <http://yaledailynews.com/blog/2008/11/14/devoted-to-devotional/>



Guided by this approach to filmmaking, I created a narrative montage that adds another layer of deterioration to the process of decay it depicts. My film begins with a complete specimen of uranium ore in an alcohol cloud, surrounded by condensation trails shooting out in all directions. A series of quick cuts acts as a cataclysmic event, fracturing the sample into pieces. Progressive scenes meander through the environment in the cloud chamber, and in each new shot the pieces of ore diminish. Eventually, fewer and smaller bits of uranium disappear entirely until only the cloud remains.

As I filmed, I tilted the base of my cloud chamber so that the particle trails seemed to flow through and between the rocks. This simulated a strange river that was neither liquid nor air. Through the gradual disappearance of the uranium ore and this simulated riverbed, I tried to give an impression of erosion. Once the video projection ends, it loops back to the beginning with a complete specimen. Thus, the necessity of looping a video for an installation becomes a metaphor for cycles of growth and decay.

*Hormesis* is my attempt to access the sublime. My presentation of radiation is characterized by many hallmarks of sublimity: a complicated paradox of fear and beauty, grappling with the infinite, and the destructive power of nature. In this paper I discuss my understanding of the sublime and radiophobia as a conceptual bedrock for *Hormesis*; my exploration is confined to Western culture and the visual arts, although I recognize that Eastern philosophies and mythologies, literature, music, poetry, and many other facets of global culture are highly relevant to those topics. Moreover, the breadth of both subjects cannot be given justice without a multi-voluminous approach, so the goal of each chapter is to weave a specific narrative that I consider most relevant to *Hormesis* rather than attempt to describe every aspect



of sublimity and nuclear fear that I encountered in my research. As a result there are many stones left unturned, but I endeavored to write a cohesive statement that elucidates the ideas behind my installation.





## CHAPTER 2

### A BRIEF HISTORY OF THE SUBLIME

Defining the sublime is like cupping water; for a moment your hands are full, but soon it is slipping through your fingers. This has not stopped philosophers from trying to encapsulate the ineffable within words. A manuscript by an unknown author, likely written in either the 1st or 3rd century AD, began the inquiry. The first popular definition was offered by the 18th century statesman Edmund Burke, a member of the British parliament and Whig party best known as the founder of modern conservative thought. Later, the topic was taken up by Immanuel Kant – perhaps *the* preeminent modern philosopher – who offered an enduring explanation that contemporary scholars build upon today.

One such contemporary philosopher, Robert Doran, published the first comprehensive account of the various theories of sublimity in 2013 titled, *The Theory of the Sublime from Longinus to Kant*. I'm impressed by his succinct and encompassing explanation that the sublime is, "united by a common structure – the paradoxical experience of being at once overwhelmed and exalted..."<sup>15</sup> The half of the paradox that Doran calls "overwhelmed" has been described by others as "terrifying" or "destructive", while the half he calls "exalted" has been called "beautiful" or "wondrous". Quintessential examples include oceans and mountains; these gorgeous landscapes could easily engulf or crush you. Sublimity confronts you with your mortality, your inevitable non-being, and the absurdity of nothingness when all you've ever known is existence.

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<sup>15</sup> Robert Doran, *The Theory of the Sublime from Longinus to Kant*, p4



An ancient, Greek fragment titled *Peri hypsos* was largely forgotten until the poet Nicolas Boileau-Despréaux translated it into French in 1674; the English title is *On the Sublime*. Its authorship is a much-debated unknown, but the text is commonly attributed to the name Longinus. This piece of literary criticism discusses writing styles good enough to be considered sublime, and it cites dozens of examples including Homer, Sappho, and the Book of Genesis. In creating a discourse on the sublime, Longinus introduced key concepts that persist in contemporary conversations, most notably its paradoxical nature. He begins his treatise by stating:

Sublimity [hypsos] is the source of the distinction of the very greatest poets and prose writers and the means by which they have given eternal life to their own fame. For grandeur produces ecstasy [ekstasis] rather than persuasion in the hearer; and the combination of wonder [thaumasion] and astonishment [ekplêxis] always proves superior to the merely persuasive and pleasant. This is because persuasion is on the whole something we can control, whereas amazement [ekplêxis] and wonder [thaumasion] exert invincible power and force and get the better of every hearer.... the Sublime tears everything up like a whirlwind, and exhibits the orator's whole power [dynamis] at a single blow.<sup>16</sup>

Here Longinus describes the sublime as overwhelming (from the Greek *thaumasion* meaning wonder, awe, admiration; and *ekplêxis* meaning astonishment, amazement, stupor) and exalting (from the Greek *ekstasis*, literally translated as a going outside or beyond oneself, self-transcendence, rapture).<sup>17</sup> In Doran's analysis, "this dual structure of sublimity is also paradoxical: on the one hand, being overwhelmed/dominated by the encounter with transcendent art or nature induces a feeling of *inferiority* or *submission*; on the other, it is precisely by being

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<sup>16</sup> Longinus, *On the Sublime*, 1.4

<sup>17</sup> Doran, p10



overpowered that a high-minded feeling of *superiority* or *nobility of the soul* (mental expansiveness, heroic sensibility) is attained. The tension between these two poles of a single experience -- of being at once below and above, inferior and superior, humbled and exalted -- produces the special dynamism of the sublime..."<sup>18</sup> Longinus' description of this powerful paradox inspired 17th and 18th century Romantics like the dramatist John Dennis, who contemplated *On the Sublime* in his critical writings. Dennis journeyed across the Alps and journaled about his experience, writing in 1688:

In the very same place Nature was seen Severe and Wanton. In the mean time we walk'd upon the very brink, in a literal sense, of Destruction; one Stumble, and both Life and Carcass had been at once destroy'd. The sense of all this produc'd different motions in me, viz. a delightful Horror, a terrible Joy, and at the same time, I was infinitely pleas'd, I trembled.<sup>19</sup>

Dennis is described by Doran as a greatly underappreciated philosopher of the sublime who was pivotal because of his "formulation of a notion of complex pleasure ("delightful horror")" and for his "singular emphasis on violent emotion".<sup>20</sup> These ideas served as the crux of Edmund Burke's highly influential 1757 treatise on aesthetics, *A Philosophical Enquiry into the Origin of Our Ideas of the Sublime and Beautiful*, wherein Burke describes the sublime as an "elevating terror".<sup>21</sup> The major contribution of Burke's *Enquiry* to the critical discourse about the sublime was creating a division between the sublime and the beautiful. Doran writes that Burke conceives of an "*oppositional relation...between beauty and sublimity, as contrasted with*

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<sup>18</sup> Doran, p11

<sup>19</sup> John Dennis, *The Critical Works of John Dennis*, p380

<sup>20</sup> Doran, p6-7

<sup>21</sup> Edmund Burke, *A Philosophical Enquiry into the Origin of Our Ideas of the Sublime and Beautiful*, p57



neoclassical aesthetics, where sublimity is considered a superlative of beauty.”<sup>22</sup> Burke explicitly contrasts the sublime and the beautiful:

For sublime objects are vast in their dimensions, beautiful ones comparatively small: beauty should be smooth and polished; the great, rugged and negligent; beauty should shun the right line, yet deviate from it insensibly; the great in many cases loves the right line, and when it deviates it often makes a strong deviation: beauty should not be obscure; the great ought to be dark and gloomy: beauty should be light and delicate; the great ought to be solid, and even massive. They are indeed ideas of a very different nature, one being founded on pain, the other on pleasure; and however they may vary afterwards from the direct nature of their causes, yet these causes keep up an eternal distinction between them, a distinction never to be forgotten by any whose business it is to affect the passions.<sup>23</sup>

Burke’s distinction that the sublime is “founded on pain” grows out of Dennis’ description of the “delightful horror” of the Alps. As Burke seeks to define the sublime in opposition to beauty, he specifies that, “Indeed terror is in all cases whatsoever, either more openly or latently, the ruling principle of the sublime.”<sup>24</sup> But he clarifies that, “when danger or pain press too nearly, they are incapable of giving any delight, and are simply terrible.”<sup>25</sup> So according to Burke, the sublime is not synonymous with terror, but rather the relief of escaping terror. He writes:

The passions which belong to self-preservation, turn on pain and danger; they are simply painful when their causes immediately affect us; they are delightful when we have an idea of pain and

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<sup>22</sup> Doran, p144

<sup>23</sup> Burke, p201

<sup>24</sup> Burke, p58

<sup>25</sup> Burke, p36





danger, without being actually in such circumstances; this delight I have not called pleasure because it turns on pain, and because it is different enough from any idea of positive pleasure. Whatever excites this delight, I call *sublime*.<sup>26</sup>

Burke's distinction between the sublime and the beautiful was famously fleshed out by Immanuel Kant, the 18th century German philosopher known as the central figure in modern philosophy.<sup>27</sup> In 1764, when Kant was in his forties, he published *Observations on the Feeling of the Beautiful and Sublime*; some scholars dismiss this as an early work written before Kant overcame "the prejudices of an era," to form his own thoughts.<sup>28</sup> However, this text is useful because it foreshadows a moment in Kant's mature writing when he conflates beauty and sublimity once again. Here Kant does not assert that the beautiful and the sublime are in opposition, but that they should be extricated from each other. So while they can sometimes exist in tandem, he distinguishes them thus:

The sight of a mountain whose snow-covered peaks arise above the clouds, the description of a raging storm, or the depiction of the kingdom of hell by *Milton*, arouses satisfaction, but with dread [or horror, *Grausen*]; by contrast, the prospect of meadows strewn with flowers, of valleys with winding brooks, covered with grazing herds, the description of Elysium, or *Homer's* description of the girdle of Venus also occasion an agreeable sentiment, but one that is joyful and smiling. For the former to make its impression on us in its proper strength, we must have a *feeling* of the *sublime*, and in order to properly enjoy the later we must have a *feeling* for the *beautiful*. (original emphasis)<sup>29</sup>

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<sup>26</sup> Burke, p51

<sup>27</sup> The Stanford Encyclopedia of Philosophy claims the distinction for Kant that he is *the* central figure of modern philosophy, <http://plato.stanford.edu/entries/kant/>

<sup>28</sup> Manfred Kuehn, *Kant: A Biography*, p142

<sup>29</sup> Kant, *Observations on the Feeling of the Beautiful and Sublime*, p208



But in his 1790 *Critique of the Power of Judgment*, Kant fully concurs with Burke that the sublime is opposed to the beautiful. Here he claims that beauty is a matter of taste while sublimity is an emotional experience. He writes that unlike the enjoyment of beauty, in a sublime experience “the mind is not merely attracted to the object, but is also reciprocally repelled by it.”<sup>30</sup> And then he elaborates that, “The mind feels itself *moved* in the representation of the sublime in nature while the aesthetic judgment on the beautiful in nature is a *calm* contemplation,” (original emphasis).<sup>31</sup> Like Burke and Dennis before him, Kant considered the sublime to be more sophisticated than beauty because it is a complex pleasure rooted in a threat of pain. However, he elaborated on their ideas with a manifold theory.

According to Kant, the resultant pleasure does not exactly arise from a relief at escaping terror; instead, it comes from our ability to reason with the terrible. Initially our senses are overwhelmed with some kind of horror, and then through contemplation we delight in our ability to make sense of why we feel that way. Making an objective evaluation of our subjective state gives us a sense of superiority, of feeling so clever that we could sort out why something feels dreadful instead of merely cowering before it. The terrible thing makes us feel inferior, and our ability to rationalize why it is terrible makes us feel superior. This is what Doran describes as the paradoxical nature of the sublime, where we feel simultaneously overwhelmed and exalted (or inferior and superior).

Kant separates the causes of horror into two categories: the mathematically and dynamically sublime. The former is inspired by an overwhelming confrontation by the infinite and the latter by the sheer, imperious power of nature. Mathematical sublimity occurs when our need to understand things in their totality, to categorize them into tidy boxes, is foiled by the

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<sup>30</sup> Kant, *Critique of the Power of Judgment*, p245

<sup>31</sup> Kant, *Critique of the Power of Judgment*, p258



impossibility of confining the infinite. Dynamic sublimity comes from our need for a greater purpose than self-preservation, to face the prospect of death with bravery because we can devote ourselves to something more lasting than our finite lives. In either case, Kant believed that our ability to recognize something greater than ourselves led to transcendence.

There is one caveat in Kant's opposition between the sublime and the beauty, and in his ideas about complex pleasure. This is the moment foreshadowed in his earlier *Observations*. In the fine arts, he believed that the sublime should also be beautiful. He writes in *Critique of the Power of Judgment* that, "Fine art displays its excellence precisely by describing beautifully things that in nature would be ugly or displeasing. The furies, diseases, devastations of war, and the like can, as harmful things, be very beautifully described, indeed even represented in painting."<sup>32</sup> And further on he elaborates that:

*Beauty* alone belongs to taste; it is true that the *sublime* belongs to aesthetic judgment, but not to taste. However, the *representation* of the sublime can and should nevertheless be beautiful in itself; otherwise it is coarse, barbaric, and contrary to good taste. Even the *presentation* of the evil or ugly (for example, the figure of personified death in Milton) can and must be beautiful whenever an object is to be represented aesthetically, and this is true even if the object is a *Thersites*<sup>33</sup>. Otherwise the presentation produces either distaste or disgust, both of which include the endeavor to push a representation that is offered for enjoyment.<sup>34</sup>

This reads like a paradox of a paradox, perhaps to the point of being utterly contradictory. I think the confusion in Kant's opinion speaks to the complicated relationship between beauty and sublimity that resulted in centuries of philosophical grappling with their relationship to each

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<sup>32</sup> Kant, *Critique of the Power of Judgment*, p312

<sup>33</sup> From Greek mythology, Thersites was a Greek soldier during the Trojan War whose character represented a person so foolish that his soul could not be cured in the afterlife

<sup>34</sup> Kant, *Critique of the Power of Judgment*, p241



other. This moment in Kant's text is like the water slipping through our fingers. Just when we thought the sublime had been articulated as a distinct experience, it folds back into confusion. Perhaps the most honest definition of the sublime is simply "ineffable".





## CHAPTER 3

### SHOW, DON'T TELL

Where words fail, images may express the ineffable. Painting, in particular, is deeply invested in the pursuit. Although earlier artworks may be classified as sublime, the first painters to explicitly strive for it are from the Romantic Era. The beginning of this painterly obsession is summarized well in a research essay published by the Tate Institution of the United Kingdom, which observes that, “It was at this point in the history of the word sublime that visual artists became deeply intrigued by the challenge of representing it, asking how can an artist paint the sensation that we experience when words fail or when we find ourselves beyond the limits of reason?”<sup>35</sup> These early attempts at painting the sublime were largely illustrative, depicting landscapes, natural disasters, and mythological moments.

Romantic painters are numerous, so I will focus on the two that have struck me most deeply before discussing a trajectory of artists who strove for the sublime, specific to my influences in creating *Hormesis*. J. M. W. Turner’s *The Shipwreck* and Théodore Géricault’s *The Raft of the Medusa* depict disaster at sea. Each painting shows a moment when a watery void threatens to swallow up limp, human figures shipwrecked beneath an ominous, gray sky. Both are large canvases, so that Turner’s tumultuous, green-gray waves threaten to engulf me as well, and Géricault’s larger-than-life human figures are like standing beside a pale corpse. Their images remind me of the warm waters in the picturesque Gulf of Mexico that I spent sixteen years living beside, as well as the numerous hurricanes that devastated its coast.

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<sup>35</sup> The Tate, *British Art and the Sublime*, <http://www.tate.org.uk/art/research-publications/the-sublime/christine-riding-and-nigel-llewellyn-british-art-and-the-sublime-r1109418>





J. M. W. Turner, *The Shipwreck*, 1775-1851, oil on canvas



Théodore Géricault, *The Raft of the Medusa*, oil on canvas, 1818-19



The painters who have had the greatest impact on my conception of the sublime are the American Abstract Expressionists of the mid-twentieth century. Barnett Newman is most famously associated with the idea because of his 1948 essay *The Sublime is Now*. In this manifesto, he eschews, “the props and crutches that evoke associations with outmoded images,” in lieu of creating an image that, “is the self-evident one of revelation, real and concrete, that can be understood by anyone who will look at it without the nostalgic glasses of history.”<sup>36</sup> His call to arms for abstract art as a direct expression of the painters’ emotional struggle demands empathy in a less literary way than the Romantics did. Thus, where the Romantics (or the Hudson River School who emulated them) might be accused of failing to articulate the ineffable in a similar fashion to their philosophical counterparts, Abstract Expressionists found a way to grasp at the sublime through a purely visual experience.

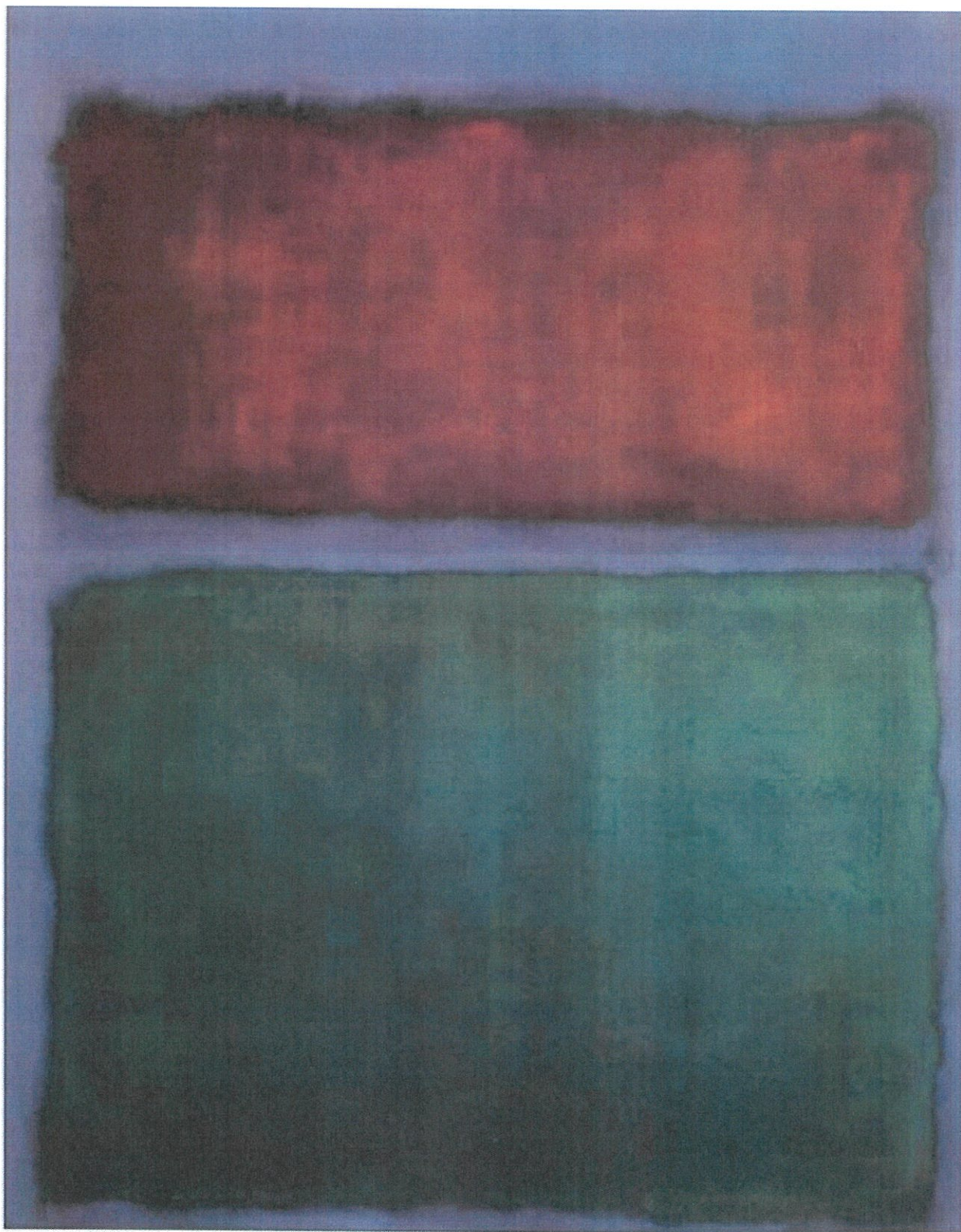
Out of all the Abstract Expressionists, Mark Rothko has impressed upon me the most. Unlike my experience of the Romantic shipwreck paintings that remind me of sublime associations like the void of the ocean or a terrible storm, Rothko paintings give me those kinds of experiences in of themselves. His color-field paintings are voids. A void is sublime because it incites the horrors of non-existence, of facing the ultimate and infinite silence that is death; it highlights the preciousness of life in perspective to its finitude. This concept permeates all of the artwork that feels sublime to me.

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<sup>36</sup> Barnett Newman, “The Sublime is Now”, *The Sublime: Whitechapel Documents of Contemporary Art*, p27







Mark Rothko, *Earth and Green*, 1955, oil on canvas





In the performance and photograph *Leap Into the Void*, Yves Klein embraces nothingness with grace. He is sure to fall, but seems like a bird taking flight. The angle of his chin, craning upward towards the sky, seems to long for the void without appearing suicidal. Frozen in a photograph, Klein's performance becomes eternal like the infinite described by Kant. But what Kant tries to explain in a thousand words, Klein encompasses in a moment exposed on film.



Yves Klein, *Leap into the Void*, 1960, gelatin silver print



When I stood inside James Turrell's *Breathing Light* at the Los Angeles County Museum of Art, I felt something like the way Klein looks in that photograph. There are no corners or other indications of terminating space in Turrell's installation, and the ambient light that slowly shifts from warm to cool made the seemingly endless room expand and contract around me. Standing at the brink of the viewing platform, I peered out in search of the wall that must surely exist but never appeared. I wanted to teeter on the edge and get as close as I could to that void; were it not for the watchful museum guard, the compulsion to leap out and find it might have overtaken me. LACMA only permits fifteen minutes per visitor, and I wonder how many of us would get lost in *Breathing Light* otherwise.



James Turrell, *Breathing Light*, 2013, LED light into space

I am attracted to voids because they are a kind of unknown, and I think that all of these artists probably were, too. The unknown is spacious enough to hold all of our hopes and anxieties. All explorers must travel towards it in search of discovery, and every trembling heart



gazes into its haze, peering at possibilities. Even once we make a thing known, it reveals a multitude of new questions; the unknown is a horizon just beyond our grasp. Author and historian Rebecca Solnit writes that:

Certainly for artists of all stripes, the unknown, the idea or the form or the tale that has not yet arrived, is what must be found. It is the job of artists to open doors and invite in prophecies, the unknown, the unfamiliar; it's where their work comes from, although its arrival signals the beginning of the long disciplined process of making it their own. Scientists too, as J. Robert Oppenheimer once remarked, "live always at the 'edge of mystery' -- the boundary of the unknown." But they transform the unknown into the known, haul it in like fishermen; artists get you out into that dark sea.<sup>37</sup>

Solnit's poetic description of the relationship artists and scientists each have towards the unknown acts on me as a clarion call. I'm exploring the kinship between art and science, and her thoughts help me discern the way we are entangled in the human pursuit of understanding. We either ask the same question in different ways, or ask different questions about the same thing. When I implicate science in my work, Solnit's description of our division of labor guides me. I ask myself how I can bring someone out into my dark sea; how did the artists I admire bring me out into theirs?

A number of contemporary artists seem to be investigating this kinship. Sometimes they work closely with scientists, like Josiah McElheny and cosmologist David Weinberg.<sup>38</sup> McElheny's *Island Universe*, which seduces me with its conceptual basis in theoretical physics and astronomy expressed in glass, light, and chrome, elegantly extend the architecture of a glass

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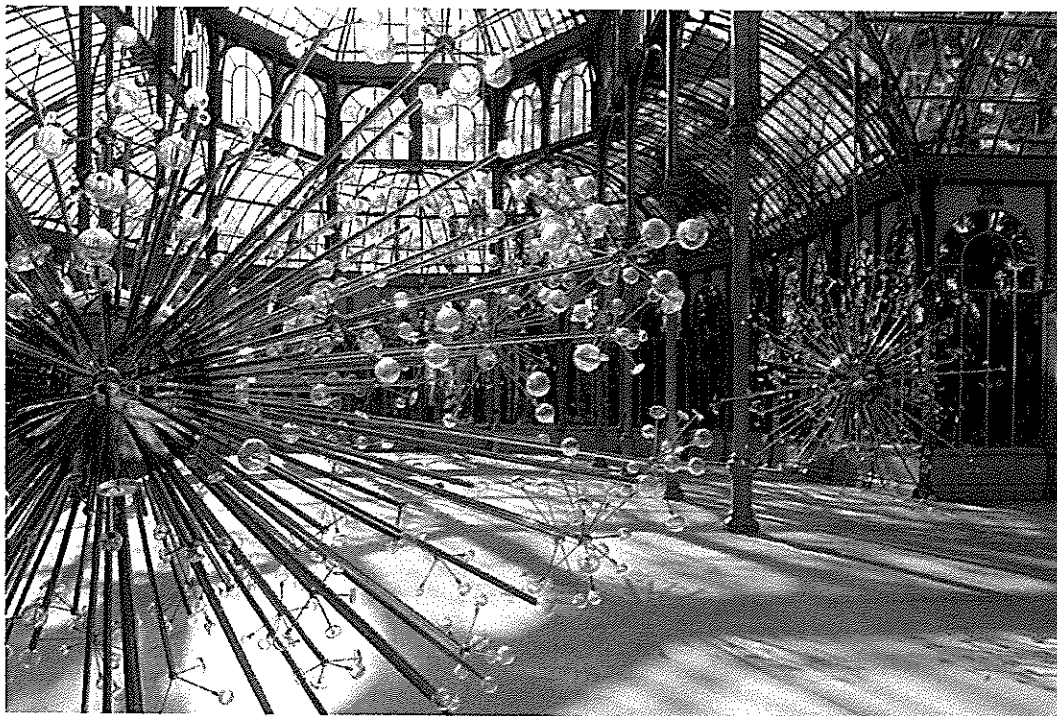
<sup>37</sup> Rebecca Solnit, *A Field Guide for Getting Lost*, p5

<sup>38</sup> David Weinberg, *Cosmological Sculptures*, <http://www.astronomy.ohio-state.edu/~dhw/McElheny/>



hall.<sup>39</sup> By virtue of this continuation the installation appears to have no artifice, which makes it seem all the more plausible an approximation of the hypothetical multiverse. I have never experienced the installation, but images of chandelier universes make me imagine that walking through McElheny's cosmology would inspire the kind of delight inspired by the infinite that Kant tried to described.

*Island Universe* graphs potential universes. They are suspended at a particular position and height in the glass hall respective to their age in the multiverse. Weinberg explains that in each bubble universe, "the rules for generating structure... might correspond to varying amounts of dark matter and dark energy or to varying levels of quantum fluctuations produced during inflation." The installation turns a cerebral theory in physics into graceful objects. Ignorance of either their determined structure or of what quantum fluctuations are would not likely dampen the experience of the work, but once that layer is peeled back the piece gains poignancy.



Josiah McElheny, *Island Universe*, 2008, blown glass, light bulbs, metal

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<sup>39</sup> Most of the work I completed in the MFA program is related to astronomy and physics.





Artists like Olafur Eliasson manipulate natural phenomena in the gallery, kind of like if the Romantics decided to discard their paints and use inspiration itself as medium. An early Eliasson piece, *Beauty*, is a lamp projected onto a water-curtain of tiny droplets. If you stand at the right spot, you see a rainbow. In an interview with Daniel Birnbaum, a contributing editor for *Artforum*, Eliasson says that, “This piece became important for me because, for the first time, it made it obvious that the spectator is the central issue. The person, the subject looking at the spotlight through the raindrops, is the issue. The water and the light and everything else are just water and light; it’s nothing really.”<sup>40</sup> *Beauty* makes an experience of art out of the act of observation.



Olafur Eliasson, *Beauty*, 1993, water curtain and lamp

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<sup>40</sup> Olafur Eliasson, retrospective catalogue, p22



MacArthur Fellow Teresita Fernández explores a “psychology of looking” in her installation above the pathways in Madison Square Park in New York City.<sup>41</sup> Her piece is called *Fata Morgana*, which is a kind of mirage. The first time I walked beneath her mirrored canopy, a light drizzle of rain multiplied and magnified the park. Later, I looked up at it in glittering sunshine and on the gray days that make every color appear more saturated. Its illusions shifted with the weather.



Teresita Fernández, *Fata Morgana*, 2015-16, suspended mirrors

An emphasis on observation crops up among these artists. Learning how to see is critical for artists and scientists alike, although they use different methods of looking. This patient task is one way to, “Leave the door open for the unknown,” as Solnit urges.<sup>42</sup> It can be a passive behavior, receptive to the indeterminate, or a searching action, assessing the unfamiliar. Observation stimulates an inquiry into the unknown.

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<sup>41</sup> Madison Square Park, <http://www.madisonsquarepark.org/things-to-do/calendar/mad-sq-art-teresita-fernandez>

<sup>42</sup> Solnit, p4



## CHAPTER 4

### RADIOPHOBIA

The existence of thousands of nuclear weapons is the most dangerous legacy of the Cold War. No nuclear war was fought between the United States and the Soviet Union, but generations lived with the knowledge that their world could be erased in a single flash of light. Cities like Prague that existed for centuries, that embodied the beauty and the talent of so much of humanity, would have ceased to exist.

Today, the Cold War has disappeared but thousands of those weapons have not. In a strange turn of history, the threat of global nuclear war has gone down, but the risk of a nuclear attack has gone up. More nations have acquired these weapons. Testing has continued. Black market trade in nuclear secrets and nuclear materials abound. The technology to build a bomb has spread. Terrorists are determined to buy, build or steal one. Our efforts to contain these dangers are centered on a global non-proliferation regime, but as more people and nations break the rules, we could reach the point where the center cannot hold.

-Excerpt from a speech given by President Barack Obama in Prague in 2009<sup>43</sup>

In 2009, the Norwegian Nobel Committee awarded President Barack Obama the Peace Prize in large part because he eloquently argued for “a world without nuclear weapons.”<sup>44</sup> At the time of this writing, the Obama Administration is overseeing the first modernization of the US nuclear arsenal since the Cold War in an expansive measure that is projected to cost over \$1

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<sup>43</sup> The White House, <https://www.whitehouse.gov/the-press-office/remarks-president-barack-obama-prague-delivered>

<sup>44</sup> Excerpt from the Nobel Peace Prize website, [http://www.nobelprize.org/nobel\\_prizes/peace/laureates/2009/press.html](http://www.nobelprize.org/nobel_prizes/peace/laureates/2009/press.html)





trillion dollars throughout a thirty year process; meanwhile, Obama's negotiations with Russia for further arms cuts have been derailed by conflicts in Ukraine. This past January of 2016, North Korea bragged about testing the deadliest weapon of them all: a hydrogen bomb.<sup>45</sup> The international community breathed a sigh of relief when seismic data suggested that it must have been a more conventional uranium or plutonium device.<sup>46</sup> If the future is bright, what illuminates it?

Today's events were precipitated by a stormy past. The world was traumatized by the atomic bombs dropped in WWII and their proliferation during the Cold War. Counter-intuitively, the threat of Mutually Assured Destruction (MAD) became the only safety net. Humanity realized it could annihilate itself with the push of a button, and probably the rest of life on Earth, too. Risk of extinction had never been so absolute.

Susan Sontag, one of the last great public intellectuals, precisely described, "...the trauma suffered by everyone in the middle of the 20th century when it became clear that from now on to the end of human history, every person would spend his individual life not only under the threat of individual death, which is certain, but of something almost unsupportable psychologically – collective incineration and extinction which could come any time, virtually without warning."<sup>47</sup> This risk of sudden extinction is evaluated annually by the Bulletin of Atomic Scientists, an organization founded in 1945 by physicists who developed the bomb but "could not remain aloof to the consequences of their work."<sup>48</sup> Every year they wind the iconic Doomsday Clock to summarize how close humanity is to utter annihilation, with midnight symbolizing the bitter end.

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<sup>45</sup> The New York Times, *As U.S. Modernizes Nuclear Weapons, 'Smaller' Leaves Some Uneasy*, <http://www.nytimes.com/2016/01/12/science/as-us-modernizes-nuclear-weapons-smaller-leaves-some-uneasy.html>

<sup>46</sup> The New York Times, *Security Council Condemns Nuclear Test by North Korea*, <http://www.nytimes.com/2016/01/07/world/asia/north-korea-hydrogen-bomb-claim-reactions.html>

<sup>47</sup> Susan Sontag, *The Imagination of Disaster*, <https://americanfuturesiup.files.wordpress.com/2013/01/sontag-the-imagination-of-disaster.pdf>

<sup>48</sup> Bulletin of Atom Scientists, *Background and Mission*, <http://thebulletin.org/background-and-mission-1945-2015>





The closest we have ever come was in 1953, the year the US invented hydrogen bombs, when it was set at two minutes till midnight. Spencer R Weart, Director Emeritus of the Center for History of Physics of the American Institute of Physics, discusses the psychological burden of this ticking clock in his 2012 book *The Rise of Nuclear Fear*:

Such great psychological danger does not accompany other materials that put people at risk of cancer and other deadly illness. Visceral fear is not widely aroused by, for example, the daily emissions from coal burning, although, as a National Academy of Sciences study found, this causes 10,000 premature deaths a year among Americans. It is only nuclear radiation that bears a huge psychological burden — for it carries a unique historical legacy.<sup>49</sup>



Martyl Langsdorf, *Doomsday Clock*, 1947, created for the cover of the Bulletin of Atomic Scientists issue (Langsdorf's husband, physicist Alexander Langsdorf, was a nuclear scientists involved in the Manhattan Project)

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<sup>49</sup> Spencer Weart, "Your Dot" Essay featured in Andrew Revkin's column *Nuclear Risk and Fear, from Hiroshima to Fukushima*, <http://dotearth.blogs.nytimes.com/2012/03/10/nuclear-risk-and-fear-from-hiroshima-to-fukushima/>



As if the unprecedented, horrific potential of nuclear apocalypse were not enough, it taps into ideas that are deeply imbedded in the ancient mythology of the Western culture that invented atomic bombs. Some of the oldest stories are about obtaining forbidden knowledge. In Greece, Prometheus defied Zeus and stole fire from the sun for humankind. Adam and Eve of the Judeo-Christian tradition ate forbidden fruit from the tree of knowledge of good and evil. When Marie Curie and her husband, Pierre, developed the theory of radioactivity at the end of the 19th century, they began a modern Promethean myth.<sup>50</sup>

Zeus took vengeance on Prometheus' theft by gifting the first woman on earth, Pandora, a jar that contained death and every evil. Pandora opened the jar and was overcome with horror, so she hastened to bottle it back up, but the only thing left inside was hope.<sup>51</sup> In a modern twist on this tale, the Curies' discovery led to humanity unlocking the power of the sun for both generating energy and packaging into bombs, and to some the nuclear waste generated by both industries is like a pestilence. For many people in a world traumatized by the bomb, it seems as though scientists opened Pandora's box – especially the Americans who worked on the Manhattan Project, a venture for researching and developing the first nuclear weapons at the Los Alamos National Laboratory in New Mexico. Fittingly, the head physicist of that program, J. Robert Oppenheimer, was nicknamed after this Greek myth in a Pulitzer Prize winning 2005 biography *American Prometheus*.

One of the Los Alamos physicists, Richard Feynman, later reflected on their research and how the efficacy of science does not come with an instruction manual on how to use it; he likened science to the Buddhist proverb, "To every person is given the key to the gate of heaven;

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<sup>50</sup> Nobel Prize biographical page on Marie Curie, [http://www.nobelprize.org/educational/nobelprize\\_info/curie-edu.html](http://www.nobelprize.org/educational/nobelprize_info/curie-edu.html)

<sup>51</sup> Hesiod, *Works and Days*,  
<http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.01.0132%3Acard%3D83>



the same key opens the gate to hell.”<sup>52</sup> Coming to terms with the great destructive potential of the nuclear weapons he helped create made Feynman deeply depressed. Seeing a new bridge under construction, he would think to himself that people were fools for building towards a future that would not exist.<sup>53</sup> He eventually concluded that science still has value because it fosters a cultural attitude that might enable humanity to transcend its hawkish differences by cultivating doubt as a mechanism for cooperation and enlightenment. In a 1953 speech to the National Academy of Science’s titled *The Value of Science*, Feynman explained:

The scientist has a lot of experience with ignorance and doubt and uncertainty, and this experience is of very great importance, I think.... We have found it of paramount importance that in order to progress we must recognize our ignorance and leave room for doubt. Scientific knowledge is a body of statements of varying degrees of certainty – some most unsure, some nearly sure, but none absolutely certain....

If we take everything into account – not only what the ancients knew, but all of what we know today that they didn’t know – then I think we must frankly admit that *we do not know*.

But, in admitting this, we have probably found the open channel.

This is not a new idea; this is the idea of the age of reason.... If we want to solve a problem that we have never solved before, we must leave the door to the unknown ajar.

...In the impetuous youth of humanity, we can make grave errors that can stunt our growth for a long time. This we will do if we say we have the answers now, so young and ignorant as we are. If we suppress all discussion, all criticism, proclaiming, “This is the answer, my friends; man is saved!” we will doom humanity for a long time to the chains of authority, confined to the limits of our present imagination. It has been done so many times before.<sup>54</sup> (original emphasis)

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<sup>52</sup> Richard Feynman, *The Value of Science*, <http://www.math.ucla.edu/~mwilliams/pdf/feynman.pdf>

<sup>53</sup> Richard Feynman, *The Pleasure of Finding Things Out*, <http://topdocumentaryfilms.com/pleasure-finding-things-out/>

<sup>54</sup> Feynman, *The Value of Science*



Feynman was not alone in searching for transcendence after confronting the destructive potential of the bomb. In *The Rise of Nuclear Fear*, Weart focuses on another ancient myth as the bedrock of nuclear imagery: the philosopher's stone, the alchemical goal of transmutation. Although it is commonly understood as the ambition to transform lead into gold, the aim of transmutation is the metamorphosis of the soul: "the true philosopher's stone – the central goal and secret of transmutation – was a spiritual matter. To achieve transmutation meant the perfection of the soul, its transformation from a dull leaden state into the golden state of divine grace and mystical illumination.... In the end transmutation became a symbol for the greatest of all human themes: the passage into death and beyond."<sup>55</sup> Weart traces historical events in tandem with imagery, mostly found in the novels and films of popular culture, which carry on the ancient hope for transmutation. He subtly reinforces Feynman's insistence that a scientific worldview is intimately associated with transcendence by describing how science became the heir of alchemy.

This inheritance seems almost intentional: Isaac Newton, perhaps the most influential scientist of all time, was also the last great alchemist.<sup>56</sup> He became famous for revolutionizing physics, but he devoted more years of his lifetime to alchemy than to those crucial discoveries.<sup>57</sup> The famous French chemist Marcellin Berthelot also forewent substantial laboratory hours to write a multivolume history of alchemy. *Les Origines de l'alchimie* was read by the English radiochemist Frederick Soddy, who, along with the father of nuclear physics Ernest Rutherford,

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<sup>55</sup> Weart, p8-9

<sup>56</sup> The Royal Society, *Newton beats Einstein in polls of scientists and the public*, <https://royalsociety.org/news/2012/newton-einstein/>

<sup>57</sup> Weart, p9





built on Madam Curie's work to pioneer research on radioactivity. Together they discovered in 1901 that the phenomena results from fundamental changes within matter.<sup>58</sup>

At the moment when they discerned the nature of radioactivity, Soddy exclaimed, "Rutherford, this is transmutation!" His partner replied, "For Mike's sake, Soddy, don't call it *transmutation*. They'll have our heads off as alchemists."<sup>59</sup> But in 1937 Rutherford published a popular science book titled *The Newer Alchemy* and in that decade it had become cliché to say that, "the famous problem of the alchemists has been solved."<sup>60</sup> Traditional alchemic transmutation required some kind of purification by fire, a passage through death that forged an individual into someone pure and holy. In the decades after Soddy and Rutherford's discovery, that holy fire turned into a flame of the nuclear variety whose survivors began new and better lives in a world purged of the more base aspects of human nature.<sup>61</sup>

Science fiction took on the task of depicting this world. One of the best-selling books on the topic was *Alas, Babylon*, written by Pat Frank in 1959, which today remains ranked among the top twenty best-sellers in science fiction short stories.<sup>62</sup> It tells of a small town in Florida determined, as the cover of the paperback summarized, "to build a new and better world on the ruins of the old."<sup>63</sup> Weart notes that, "In *Alas, Babylon* and other stories, disaster did indeed leave protagonists more strong and loving.... No idea could have been more dangerous. Perhaps an individual personality does need to go through chaos before it can hope for full rebirth. However, to suppose that an entire civilization can be redeemed by passing through catastrophe

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<sup>58</sup> Weart, p3

<sup>59</sup> Weart, p3

<sup>60</sup> John A Eldridge, "Famous Problem": *The Physical Basis of Things*

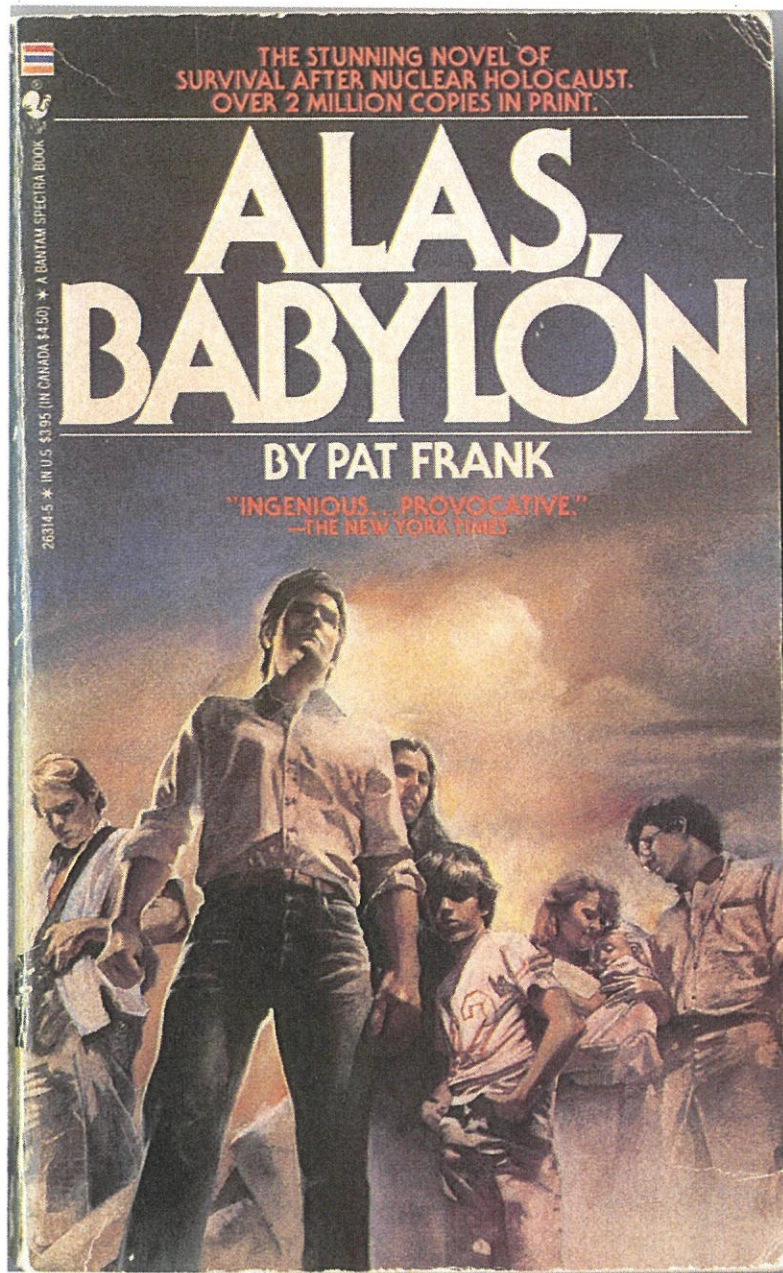
<sup>61</sup> Weart, p9

<sup>62</sup> Amazon.com best seller list, [http://www.amazon.com/gp/bestsellers/books/16308/ref=pd\\_zg\\_hrsr\\_b\\_1\\_4\\_last](http://www.amazon.com/gp/bestsellers/books/16308/ref=pd_zg_hrsr_b_1_4_last)

<sup>63</sup> Pat Frank, *Alas, Babylon*, cover of 1980 reprint



– that is a dangerous fallacy. Wars do not leave most people more loving and creative.”<sup>64</sup> But other science fiction stories were not so treacherously optimistic.



Pat Frank, cover of *Alas, Babylon*, first published in 1959

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<sup>64</sup> Weart, p128-9



Another best-selling novel, *On the Beach*, and its 1959 film adaptation take place in Australia, whose citizens were untouched by the nuclear apocalypse of the Northern Hemisphere but waited for a slow death as fallout blew southward. The film ends with miles of empty streets in Melbourne. Weart “found that even a quarter-century later people remembered *On the Beach* with strong emotion. The audiences were drawn into Kramer’s busy world of decent, ordinary people, then watched that world gradually die away.”<sup>65</sup> Thus the possibility of transmutation comes with a great risk -- if the fire does not purify, it merely destroys. More than a decade after the US bombed Japan, *Alas, Babylon* and *On the Beach* offered opposing takes on the result of nuclear apocalypse.



Directed by Stanley Kramer, still from last scene of film, 1959, based on 1957 novel by Nevil Shute

The nuclear fire that might purge the Earth has to be kindled by somebody. As alchemists evolved into scientists, the Faustian wizard in his mountaintop lair became the mad scientist in a Dr. Frankenstein laboratory, and in either guise the archetype symbolizes an

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<sup>65</sup> Weart, p125



individual meddling with nature. Weart writes that, “Such an individual might release pestilence, demons, and other evils, as witches did, or might simply propagate heretical ideas, as some protoscientists in fact did. People have always feared that an overweening individual, through evil thoughts or magical acts, might contaminate neighbors or the entire community.”<sup>66</sup> When the anti-nuclear movement blossomed in the face of bomb proliferation, this corrupt individual began to look like an abhorrent government authority.<sup>67</sup> An infamous incarnation is General Ripper in Stanley Kubrick’s Cold War satire *Dr. Strangelove*.



Stanley Kubrick, *Dr. Strangelove or: How I Learned to Stop Worrying and Love the Bomb*, film still, 1964

Worries that nuclear fire might either purify an individual or tempt an evil mastermind were played out in brightly colored spandex within comic books and Saturday morning cartoons.

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<sup>66</sup> Weart, p15

<sup>67</sup> Weart, p142-3





Stan Lee, the prolific creator of Marvel Comic characters, invented a beloved handful of radioactive heroes: the Fantastic Four (empowered by cosmic radiation), Spider-Man (bitten by a radioactive spider), and the Hulk (a physicist hit by a nuclear ray).<sup>68</sup> From rival DC comics, the iconic Superman realized that his one great weakness was glowing, green kryptonite and learned that his home planet was blown up in an atomic apocalypse.<sup>69</sup> These superheroes frequently faced off against monsters created by exposure to nuclear experiments and waste, or they foiled villains hell-bent on controlling the world with nuclear reactors and death rays. Good and bad guys alike were born out of nuclear transmutation in these modern myths.



An even more literal example from the comics

<sup>68</sup> Weart, p224

<sup>69</sup> Weart, p106



The only thing Pandora was able to trap inside her jar was hope; at times it may seem that in the modern Promethean story hope is still sealed away, perhaps locked underground in a bomb shelter. But the transmutation metaphor suggests that trauma from the existence, use, and proliferation of nuclear weapons leaves room for hope along with despair. Perhaps, like the plot in *Alas, Babylon*, this hope is dangerously foolish. Within the contemporary climate of nuclear threat, humanity may be facing a choice between transcendence and extinction. In 2016, the nuclear doomsday clock is set at three minutes till midnight.<sup>70</sup>

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<sup>70</sup> Bulletin of Atomic Scientists, <http://thebulletin.org/>



## CHAPTER 5

### CONCLUSION



Installation shot of *Hormesis*, 2016



*Hormesis* begins with two walls that extend out from a corner in a gallery. They are two feet deep, wide enough to comfortably fit a column of text. These cautionary words turn the act of ingress into a choice, so that this threshold is a major moment in the installation:

If you enter this room,  
you will be exposed  
to gamma radiation  
from uranium ore.

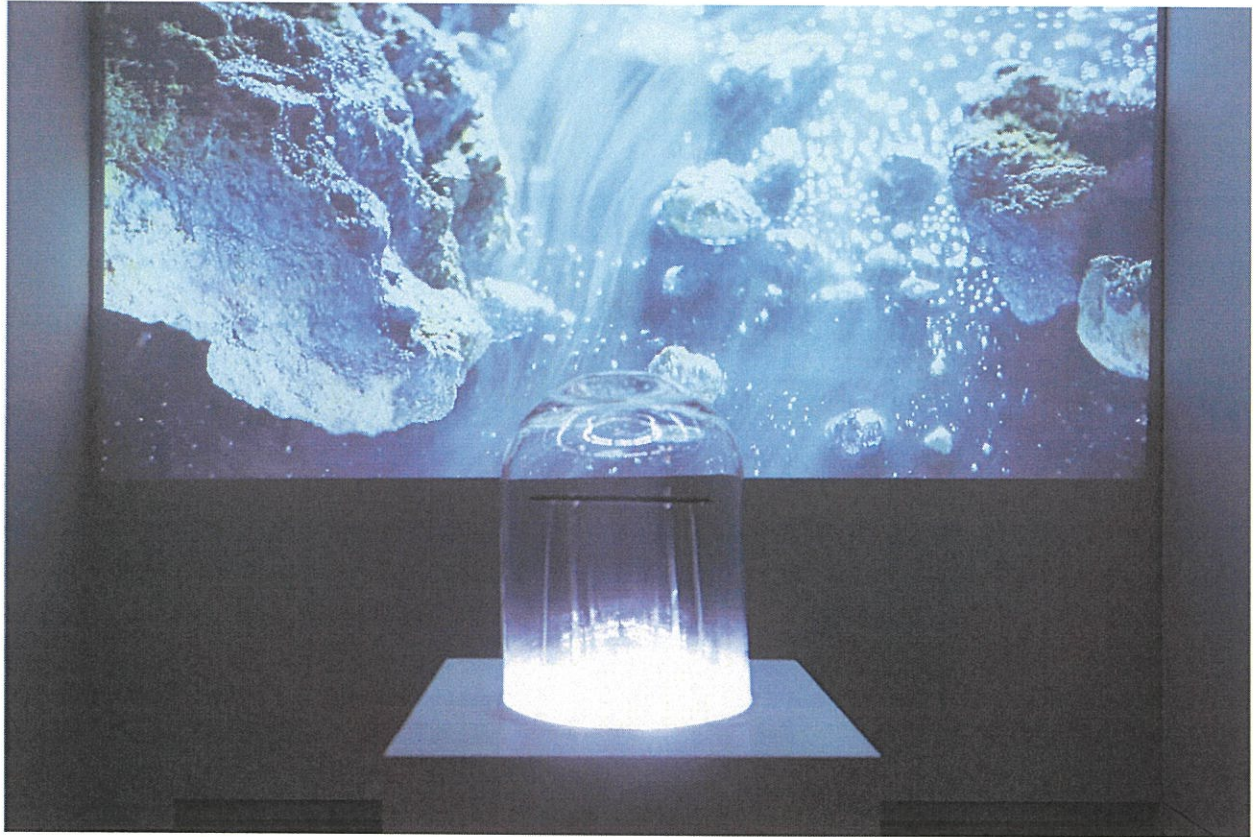
Scientists do not know  
what low doses of radiation  
will do to you.

But,  
if you confront this unknown,  
you will have the opportunity  
to observe the imperceptible.

Viewers are confronted with an unknown; acute radiophobia may prevent entrance. A video projection fills the far wall of the room; viewers can peek at it from the threshold but must enter and turn right to see the entire frame. It acts as a lure to attract viewers, whereas the text may serve as a repellant. Those who enter find themselves in a small room lit only by this projection and a narrow pedestal in the center of the space. Both light sources cast the same quality of bluish light -- a soft shade of twilight.







Installation shot of *Hormesis*, 2016

If you stand facing the projection, the pedestal is centered before it like an altar. It is capped with a glass dome that reflects and abstracts the moving images in its curvature. The particles moving in the film resemble snow. During much of the film, the “snow” seems to fall into an alien riverbed, but the landscape bears enough resemblance to the specimen in the cloud chamber that it becomes evident that it was recorded through the glass. *Hormesis* is silent.

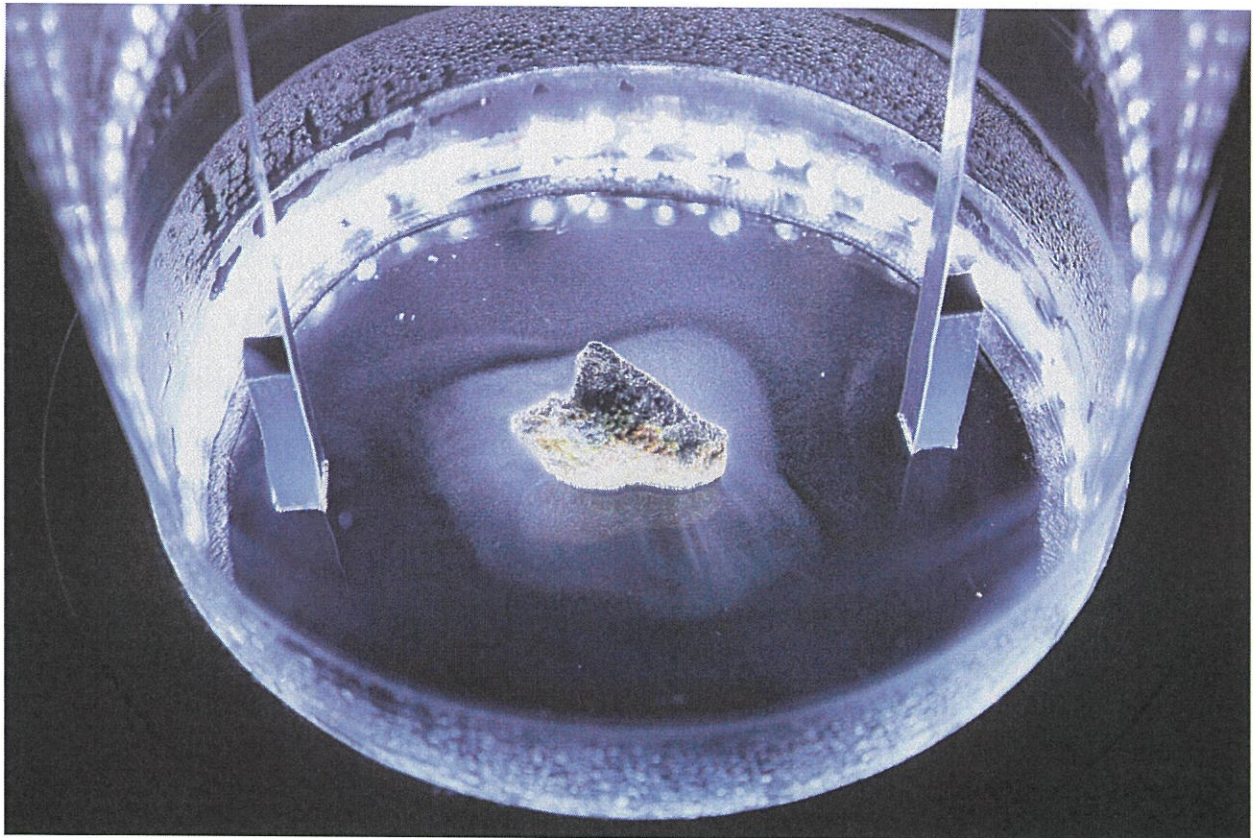
The pedestal can be approached from any direction, and its central placement encourages a circular walk around the room. It’s a standard, white cube piece of gallery furniture, tall and narrow, with a bell jar sitting recessed into the top. Built into the perimeter around the glass are LED lights shining onto the bottom of the chamber, which is a black, metal plate. Two narrow, reflective metal supports emerge out of the plate to hold up a rectangle of black felt saturated





with pure isopropyl alcohol. As the room temperature alcohol evaporates and settles to the bottom of the chamber, dry ice concealed beneath the black plate cools the vapor so rapidly that it supersaturates into a cloud.

The alcohol cloud engulfs a specimen of uranium ore positioned between the metal supports holding up the isopropanol reservoir. Throughout the exhibit different samples were showcased in the chamber, sometimes gray with brilliant, emerald crystal growths, or black with red, orange, and mossy streaks. At other times, it was an unassuming and small gray stone. Radioactive particles emitting from the rock create condensation tracks in the cloud, which appears denser around the sample in stratified waves that undulate outwards in all directions. A few wispy tracks shoot out and curl towards the glass.



Installation shot of *Hormesis*, 2016



The subtle, graceful movement in the bell jar appear markedly different than the effect produced by the particle detector in my studio; there, it was like a firecracker of wide tracks shooting out in all directions, fast and forceful. This high level of activity was pre-recorded in the video, and its projection in the installation created a contrast between the great and the gentle. There was not supposed to be a gulf between the particle detector and the film; I wanted maximum visibility of the subatomic world. A team of CU Boulder physicists came to help figure out what went wrong the day before the show opened, but they were only able to confirm my suspicion that the 30% increase in humidity in the museum, which has a climate controlled environment, substantially stifled the cloud chamber's ability to detect particles. I made the invisible visible... but just barely.

It felt like a heartbreaking failure. Upon reflection, I realized that my distress was the most honest expression of my fascination with the unknown. The possibility of making the invisible visible tantalized me, and it was such an exciting possibility that it did not matter to me that I might not know enough about physics or engineering to fully realize my goal. When I decided to build the cloud chamber, I did not realize how difficult it would be. I had to overcome a series of unforeseen technical problems along the way, and succeeded in solving all of them until the museum's humid environment provided one last hurdle that I could not resolve in time.

Four days after *Hormesis* opened, I re-watched the 2013 documentary *Particle Fever*, which chronicles the hopes and anxieties of CERN physicists firing up the Large Hadron Collider for the first time. The LHC is a particle accelerator and the largest machine humanity has ever built, a contemporary wonder inheriting the legacy of the Library of Alexandria, the Great Pyramid of Giza, and the ancient paintings in the Chauvet Cave. I've seen the



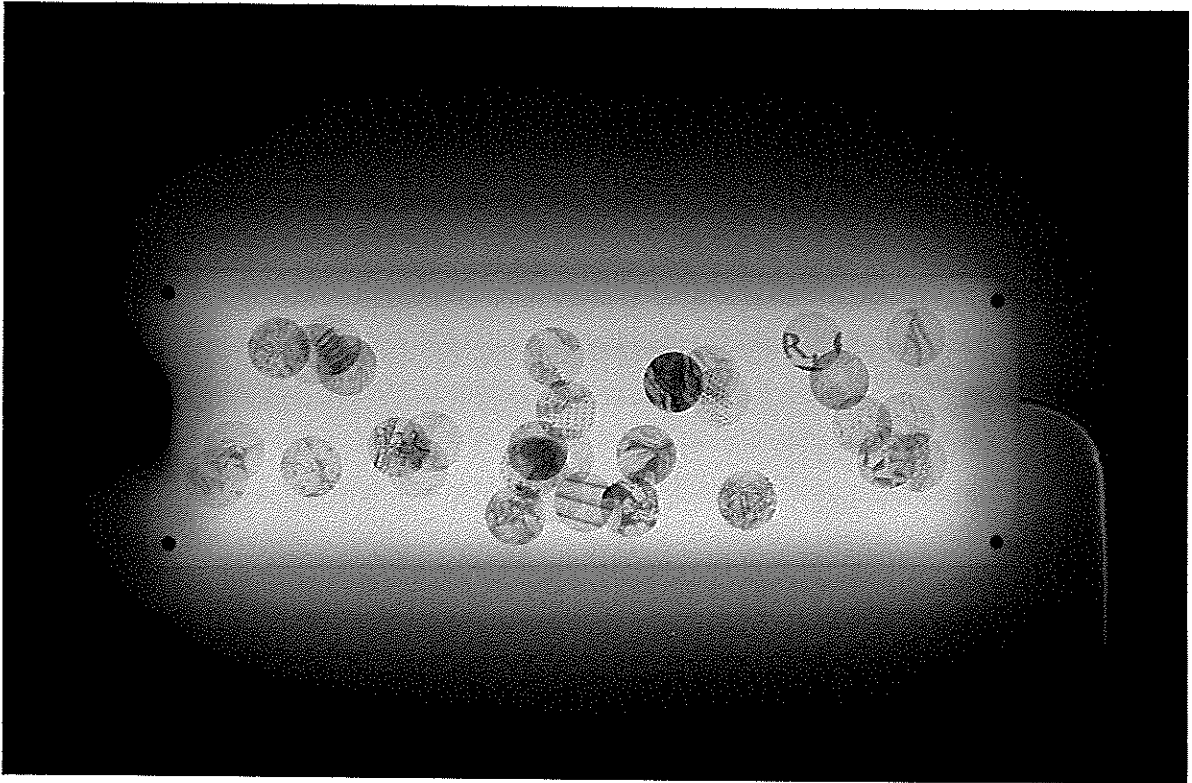
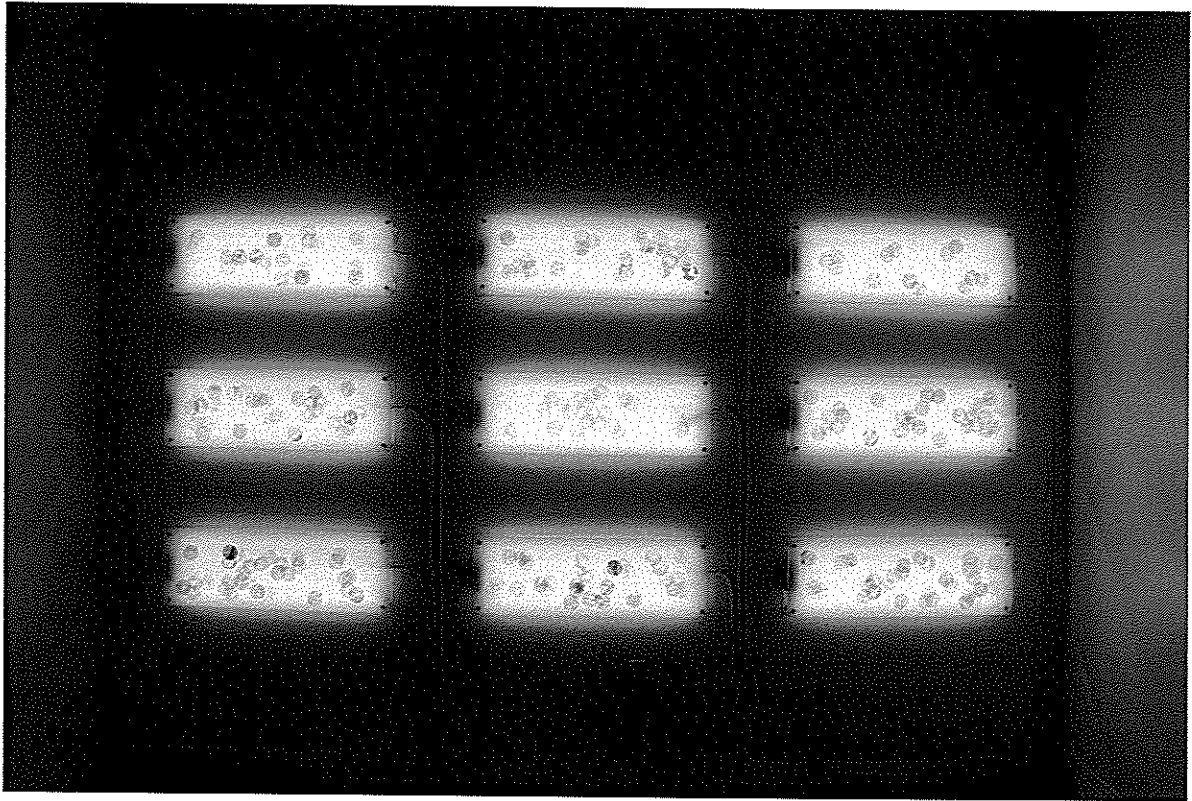
documentary several times, but my experience building the particle detector filled me with immense empathy for the scientists' setbacks and fears of international embarrassment. A Stanford theoretical physicist featured in the film, Dr. Savas Dimopoulos, remarked that the key to success is jumping from one failure to the next with undiminished enthusiasm. Their struggle reminded me that heartbreak from this kind of failure is only possible if you plunge yourself into an exciting unknown.

Taking risks with unfamiliar technologies to realize an art piece has become a defining part of my practice. Because I enjoy learning about how things work, embarking on a project that forces me to figure out the unfamiliar is exhilarating. Setbacks along the way can be immensely frustrating and depressing, but the emotional lows make the "ah-ha!" moments so much more joyful. My work is not purposefully about technology, but exploring materials previously unknown to me has become necessary for putting form to ideas. The concepts *Hormesis* and past installations explore include the relationship between micro and macro perspectives, visualizing spacetime, rendering the invisible visible, and exploring voids.

One such installation is *Slice of Life*, a grid of nine, 1x3ft acrylic lightboxes that resemble enlarged microscope slides. The milky white panels are back-lit by rows of LED in an otherwise dark room, and some of the light reflects back onto the wall in horizontal bands and criss-crossed patterns. I mounted hundreds of drawings on small circles of translucent vellum inside the lightboxes, scattered and overlapping like Venn diagrams. Each graphite sketch was rendered while looking through a pocket microscope at items mined from my environment (things lying around the studio, found on walks home, or tucked into the nooks of my bookshelves). Off to the side on the wall, where the patterned light fades into a subtle gradient, is a specimen list of everything I drew.



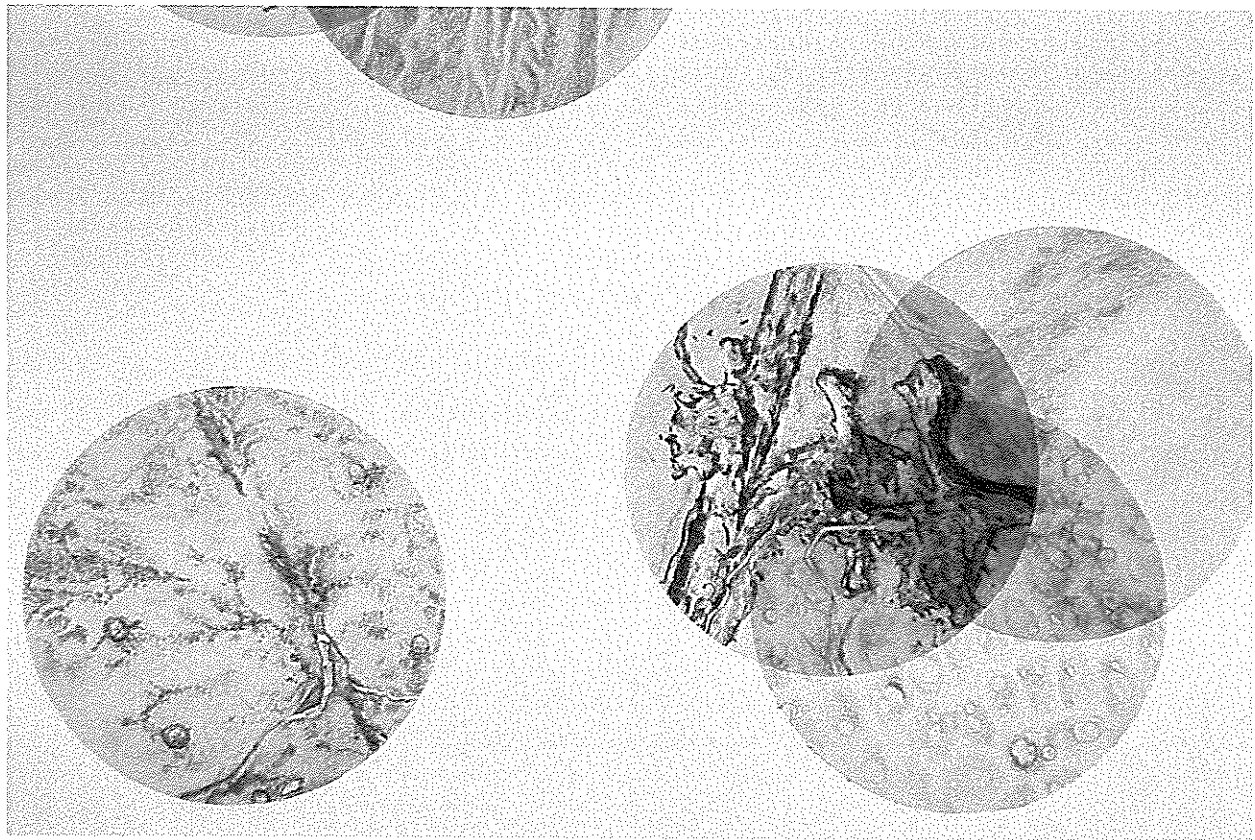




Installation shots of *Slice of Life*, 2015



*Slice of Life* required that I start learning about electronics, and figure out how to mount acrylic sheets attached to copious power cords in a way that conformed to the minimalist, austere aesthetic that I wanted to achieve. Visual information from a life lived is given in the drawings, but their stochastic placement defies the rigid 3x3 grid that holds nine panels together in a composition. I don't reveal which drawing corresponds to which item on the specimen list, and ultimately little concrete knowledge about living is informatively described. But, it represents a normally invisible way of seeing the ordinary, from a perspective much smaller than the dimension of one centimeter through which we usually perceive the world. Images of the microscopic allow us a glimpse of the infinitely complex depth of every corner of the cosmos.



Detail of *Slice of Life*, 2015

Another installation, *Tunnel*, was site-specific to a long hall with a facade of south-facing windows. Before I blacked out the walls and fitted the windows with a mural-sized map of the



Milky Way, I'd walked through this hallway almost daily for over a year and knew how the light moved across it as the sun traveled from east to west. The success of the piece depended on how natural light behaved within my intervention, and my risk in this piece was investing a lot of labor without certain payoff, while learning how to cut pinholes in delicate, navy paper using a rough CNC router that I could program with an accurate star map. Weather and time of day drastically affected viewers' experience of the piece. If someone walked through *Tunnel* during sunrise, the circles of light were the color of blood oranges and pink cherry blossoms; clouds obscured light entirely and deadened the installation, until peaking sunbeams made it flicker back to life.



Installation shot of *Tunnel*, 2014

*Tunnel* used the light of one star, our sun, to represent an entire galaxy of stars. It offered little surprises, like pinhole images of upside down mountaintops, treelines, and sunspots





repeated in hundreds of circular pricks of light. A dark tunnel, especially one transformed into an experience of astronomy, invites metaphors of voids like black holes or the infinity of deep space. The architecture of the hallway invited a bodily relationship to our place in space and time, such as how viewers could walk through the Milky Way in under a minute, or stop to linger in a single constellation. It was kind of like the inverse of *Slice of Life* in that it represented the macrocosmic rather than the microcosmic at the normal dimension of one centimeter.



Installation shot of *Tunnel*, 2014

All of these installations evolved out of my background in painting and drawing; I painted on increasingly larger canvases until it seemed more intuitive to open the composition up to an entire space, and that trajectory led to my creating installations. The last painting series I completed dealt with similar preoccupations that I explore in *Hormesis*, *Slice of Life*, and *Tunnel*, especially themes of scale and representing time through space. It was a series of charcoal





figures mixed with washes of oil handled like cloudy nebulae, that looked like layered snapshots of the figure moving through time, in the tradition of Duchamp's *Nude Descending a Stair, No. 2*, and the contemporary British painter Jenny Saville. They were my expression of Carl Sagan's romantic interpretation that we are star stuff. Each figure is caught either coalescing into a person or dissipating back into mere matter, likening the provincial human figure to the expansive, expanding universe.



*Portrait of Richard Feynman, 2013*



*Hormesis* represents a temporary culmination of my exploration into these themes. I began with painting the body, and then grew to position the bodies of my viewers within an environment. Both my paintings and installations ask questions about the relationship of bodies to the micro and the macro. A viewer walking through *Hormesis*, who steps between the tiny phenomena in my particle detector and the immersive environment projected in my video, completes a continuum of scale. This acts as a metaphor for infinity reaching out in all directions, the contemplation of which Kant called sublime. More successfully than any of my



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