

AWAKENING WONDER: AN INTERACTION OF ART AND SCIENCE

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by

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## AUTHORIZATION TO SUBMIT THESIS

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## ABSTRACT

Art and science have a particular way of combining to elicit wonderment from a generation that, in the face of unimaginable technological advancement, is at risk of losing touch with their sense of wonder. In particular, the aesthetic of scientific apparatus of the Enlightenment period is examined for its potential to inspire reflection and creative thought, even in artistic simulation. The particular body of work explained here visually mimics the *wunderkammern* of Renaissance and Enlightenment Europe, as well as 17<sup>th</sup> and 18<sup>th</sup> century scientific equipment, made primarily of brass and glass, in an attempt to harness that inherent propensity to re-awaken a sense of wonder in those for whom it may have faded.

## ACKNOWLEDGEMENTS

I would not be where I am today if it weren't for the unfailing support of so many people; in particular, I probably wouldn't have graduated from USU without the love, time, and attention of Bob Winward, Fran Titchener, and Mark Damon. I also have Bob to thank for somehow knowing the perfect time to nudge me towards my grad school experience here, at University of Idaho, with Delphine Keim.

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And lastly, to the friends I've made over the last three years. You know who you are, and hopefully you know that I'll cherish our friendship forever.

## DEDICATION

To my family, who mean everything to me, and especially my parents, Jim and Jeanne, whom I love and appreciate beyond words, whose support and encouragement have made this endeavor possible, and who opened my young mind to science, art, and wonder.

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## CHAPTER 1: INTRODUCTION

*The dignity of the artist lies in his duty of  
keeping awake the sense of wonder in the world.*

—*Marc Chagall*

I carried a small notebook in my backpack at all times during high school. In an era before near-instantaneous internet searches and high speed data, I would write down unfamiliar names, ideas, and words throughout the day, to look up on my lunch hour or after school at the library. I learned many wonderful things by taking physical books off of shelves and losing myself in their pages.

It has become a cliché of history for every generation to feel as if it is poised on a cultural, moral, or intellectual precipice, to see the next generation as fundamentally diminished. At the risk of falling into such a cliché, I cannot help but remark that the students I have had the opportunity to work with have lost *something* in the way they engage with and appreciate the world around them. I would have been intoxicated with the ability they have to access all of human knowledge at their fingertips, but the “millennial” generation seems almost numb to it. Numb not only to the vastness of the information they retrieve daily from a global network of supercomputers, but also indifferent to the miracles of technology that deliver that information from around the world, instantaneously and wirelessly to the miniature computers they hold in their hands. I fear that this generation is losing its sense of wonder.

I believe art is one way to reawaken that sense of wonder—in particular art that combines and interacts with science. There is a dynamic in the overlap of the two disciplines that is broadly engaging, is deeply rooted in creative thinking and heuristic learning, and elicits wonder to positive effect.



## CHAPTER 2: CONCERNING WONDER

*For it is owing to their wonder that men both now begin  
and at first began to philosophize.*

—Aristotle

Wonder is most commonly defined as the reaction of the human mind to something it cannot analyze or catalog based on previous experience. It is the emotional stimulus that primes our uniquely human capacity to ask deeply: Why? Wonder can be found at the fringes of human knowledge and experience, it exists in the spaces where our most fundamental disciplines overlap, and it is a common link between differing or seemingly irreconcilable worldviews, like science and religion. It is an intellectual, emotional, and spiritual catalyst; an irreducible element which precipitates and crystalizes many pursuits of human knowledge and expression.

For millennia, Western philosophers have recognized the important role wonder plays in the advancement of both individual and collective understanding. Perhaps most famously, in *Theaetetus*, Plato quotes Socrates as saying that wonder (*thaumazein*) is the very beginning of philosophy. Plato's valuation of wonder was not entirely positive, though. Another word he used for wonder, *deinon*, "can connote that which is strange or uncanny, terrible, fearful, or dreadful." Before science had driven the unknown and the uncanny from daily life, things which could not be analyzed or cataloged were discomforting, even potentially threatening. And Aristotle, while agreeing with Socrates about the value of wonder in philosophy, placed emphasis on it as a condition of not-knowing, or as only the first step toward the higher goal of knowledge in full.

In the "First Part of the Second Part" of *Summa Theologica*, under "Question 32: The Cause of Pleasure," Thomas Aquinas characterized the unease some ancient philosophers and religious thinkers felt about wonder in the proposed Objections to "Article 8: Is Wonder a Cause of Pleasure?" His Replies to the same article, however, affirm his own belief that wonder can indeed be a pleasurable thing, and his attitude heralded a transition toward the appreciation of wonder in extraordinary ideas, objects, and places. The Middle Ages saw an increasing fascination with

new and wonderful curiosities, including the first mass printings of travel guides to exotic lands barely hinted at on the edges of most maps. As far back as the first century BCE, natural historians had “documented” the incredible existence of faraway countries, inhabited by dog-headed humans, birds big enough to prey on elephants, headless giants with faces on their torsos, and plants that sprouted sheep and devoured people. But the Middle Ages saw the first dissemination of fantastic images of these wonders. One of the pioneers of what we would call the encyclopedia, Gervase of Tilbury, characterized this climate of discovery in his own such book, *Otia Imperialia*:

We embrace things we consider unheard of, first on account of the variation in the course of nature, at which we marvel; then on account of our ignorance of the cause, which is inscrutable to us; and finally on account of our customary experience, which we know differs from others’... From these conditions proceed both miracles and marvels, since both culminate in wonder.

In addition to acquiring stories and images of the world’s wonders, scientists and wealthy collectors assembled specimens from previously unexplored corners of the natural world, and placed them alongside curious artifacts from ancient civilizations and foreign countries, as well as small masterpieces from contemporary artists. These *wunderkammern*, or cabinets of curiosity, cultivated the inquisitive and explorative spirit that would define the scientific revolution of the 16<sup>th</sup> century, by presenting opportunities for wonderment in a contained and curated way. (Figure 1)

Wonder also fueled advancements in Renaissance art, removing it from its almost entirely religious setting to private collections and civil institutions, and prompting scientist-artists like Leonardo da Vinci and Albrecht Dürer to investigate more accurate methods of representation. Their contributions to the realistic depiction of perspective, human anatomy, and motion, not to mention developments in new artistic methods and materials, had the power to provoke a sense of wonder in the individuals who were—and are still—able to view their masterpieces.

There were still philosophers who viewed wonder with suspicion, and this attitude became more prevalent as the Enlightenment spread across Europe. One of the scientific giants of the era, Francis Bacon, considered wonder to be a form of “broken knowledge,” or ignorance that

could only be fixed by learning and intellectual discovery. René Descartes, one of the Enlightenment's great philosophers, also regarded wonder with distrust. Wonder was a driving force behind the scientific inquiry that characterized the 17<sup>th</sup> and 18<sup>th</sup> centuries, and Descartes acknowledged its necessary role in asking and answering philosophical questions. But, he also maintained the notion that wonder is pre-knowledge, incomplete, and should not be entertained in the mind for any length of time, and for anything other than formal rational inquiry. This promoted a sort of false taxonomy of wonder, rarifying and validating the wonder of the philosopher, while devaluing and discouraging wonder in those of “common” intelligence.

Of course, some of the most significant advancements of the Enlightenment were made by “common” people, men and women with no background in learning or philosophy. The word “philosophy” was used to describe all sorts of investigation, experimentation, and classification, from chemistry and physics to language and economics. The term could be applied to any body of knowledge—many of the disciplines we now think of as “science,” for example, were once the purview of “natural philosophy”—and the etymology of the word, itself, “the love of wisdom,” encapsulates the spirit of the Enlightenment era. Amid political instability and religious reformation, an individual imperative to understand the universe flourished. Men gathered in numbers not seen outside the Church in centuries, to discuss existential matters and share knowledge, and wonder was slowly reevaluated as a positive, essential component of discovery, innovation, and the acquisition of knowledge.

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A large portion of my thesis exhibition is housed in an antique glass display case, of the sort often used to exhibit scientific specimens and curio collections; this is with deliberate reference to the *wunderkammern* and scientific exhibitions of the 17<sup>th</sup> and 18<sup>th</sup> centuries. (Figure 2) Combined with the many suspended machines—what I call my “apparatus”—and various light catching/reflecting bulbs and lenses (Figure 3), my intention is to create a small, transformative space where, as Lawrence Weschler says of the Museum of Jurassic Technology, “[the viewer] continually finds himself shimmering between wondering-at (the marvels of nature) and wondering-whether (any of this could possibly be true).” Or in the case of my exhibition, I

would like viewers to wonder whether my apparatus and various collections could possibly be real and historic, because that prestidigitation prolongs the wonder of not knowing.

Curating collections as works of art is a new development in my practice. I have long admired the work of one artist in particular, Joseph Cornell, who defined his art career with collecting and assembling strange, discarded or disowned, and seemingly unrelated objects into exquisite collages and “constructions.” He had a talent for crafting small assemblages with the illusion of function in their components, and with hints of dignified but inexorable deterioration. He combined random trinkets, star charts, nature illustrations, clock and game parts, sand, and weathered plaster and paint to tell a seemingly arcane story, arranging the objects in antique boxes with a patina of long forgotten purpose. (Figure 4) I continually find details tucked into the corners of his boxes, and so I find continual wonder in his work, some of which is now nearing 100 years old.

I have learned that carefully chosen objects can develop new meaning in context with other objects, and can elicit wonder in their presentation of combinations never encountered before. As is commonly said, the whole really can amount to more than the sum of its parts. The arrangement of multiple objects engages the pattern recognition and problem solving centers in the brain, and viewers are drawn not only to the items collected, but more rewardingly, to the *space between* the items, the possible connection of one to another to another. The power of an artwork-collection to instill wonder and speak directly to another human being comes from the pleasure of filling the narrative gaps between objects with our own individual stories.

*Toy Chest* is a small wooden case with several shelves, on which are lined up salvaged glass vials filled with mechanical toy parts. (Figure 5) The toy parts are not recognizable as such, removed as they are from their various plush linings and plastic housings; they appear simply as tiny springs, washers, nuts, bolts, cams, levers, and pins. Other small collectibles are interspersed with additional vials containing items from my own childhood, or items that evoke a childlike wonder in me even today; gems and rocks, a fossil bear claw, a tiny knight in shining armor, an ancestral Civil War uniform button, a Celtic era bronze bell, Roman tesserae, sea glass, ancient jewelry, and unique objects collected on countless walks in diverse places. The work references

childhood, the state when philosophers, scientists, and theologians all agree that human beings experience the most wonder, qualitatively and quantitatively. The “bottling up” of these curiosities performs the same function that science served in collecting and classifying the wonders of the natural world. And for each object that is observed and mentally cataloged, while the wonder of it no longer persists, the memory of that wonder abides, remains accessible, and retains its value.

The logic at work in *The Keys* is more cryptic; graduated shelves in a worn wooden box hold 30 rings, arranged in four rows, each cast in brass or silver with a unique pattern, seemingly unrelated to any of the others. (Figure 6) When viewing the artwork as a whole, perhaps the greatest source of wonder is the diversity of pattern designs, and the possibility of a connection that somehow unites them. Once again, I am content to let the truth of what binds them together—all the designs are facets of my character, fragments of my memories, passions, and intellectual interests—remain obscure, in order to allow the viewer to integrate their own narrative. An additional source of wonder is suggested in the name of the piece; there is an unfamiliarity and perplexity at being confronted with one object (ring) which has been labeled as another (key). Could each ring actually be a physical key, somehow encoded to unlock a door or hidden space? Are the rings keys to specific meanings, symbols comprising a kind of legend or mapping system? It begs for a completely new analysis of the various designs in context of the additional information, and allows a new layer of wonder to settle over the initial visual experience of the piece.



Figure 1: The *Wunderkammer* of Olaus Wormius



Figure 2: MFA Installation, case interior



Figure 3: MFA Installation

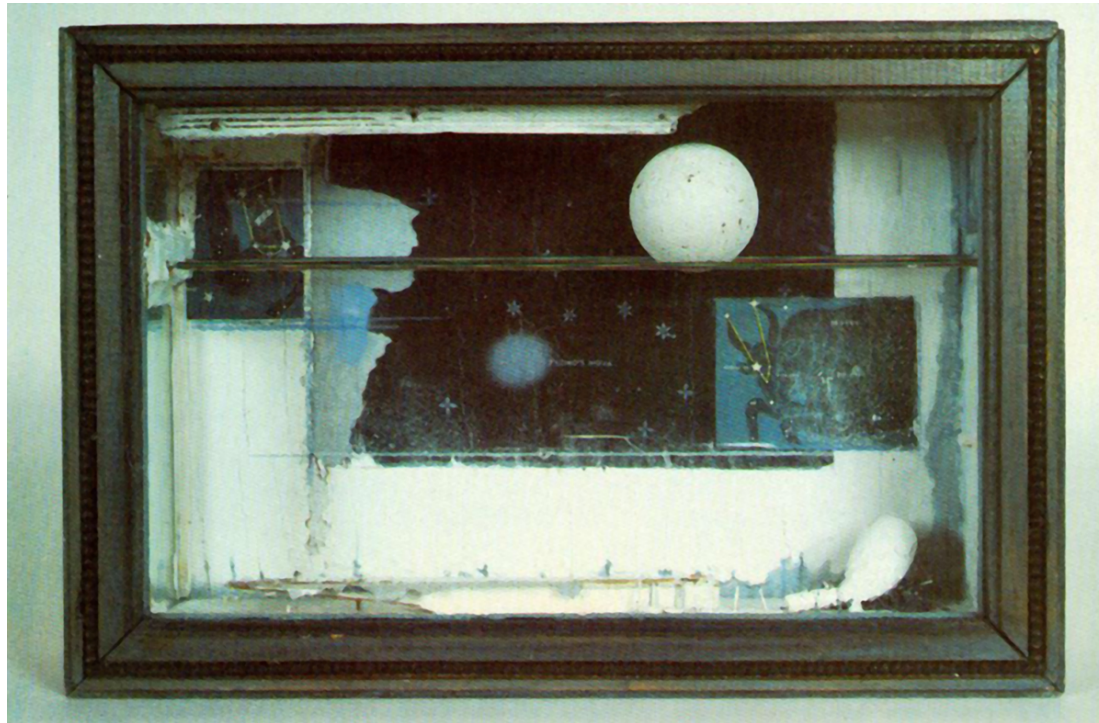


Figure 4: *Cassiopoeia 1*, Joseph Cornell c. 1960  
Construction, 9.875 x 14.875 x 3.75 inches; Estate of Joseph Cornell



Figure 5: Toy Chest

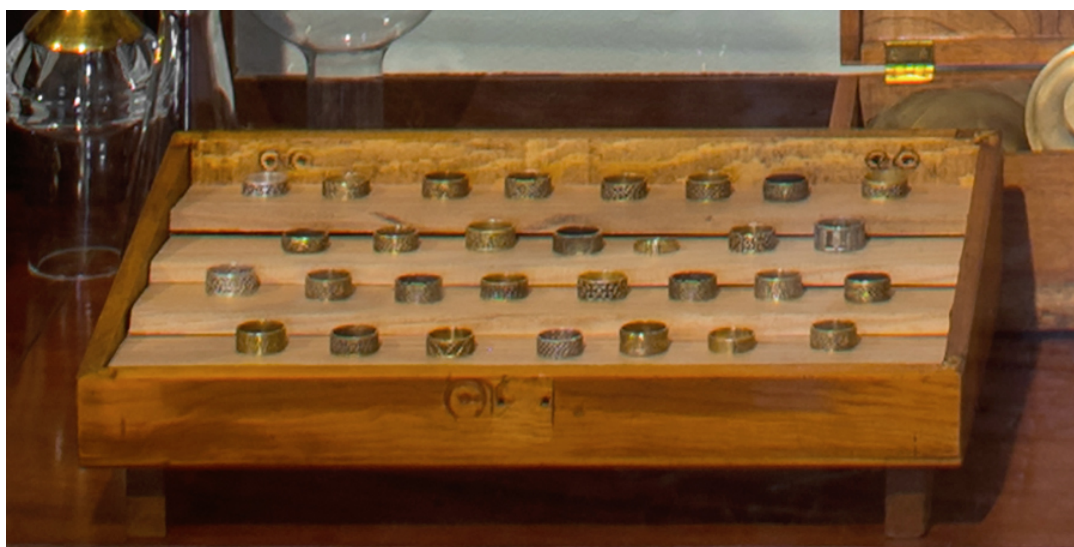


Figure 6: The Keys



## CHAPTER 3: SUBSTANCE OF ENLIGHTENMENT

*SAPERE AUDE*—*Immanuel Kant (quot. Horace)*

If wonder was the essence of the Enlightenment, two specific materials gave it substance: brass and glass. Though both had been in use for thousands of years by the 17th century, they were not regarded as materials of great precision until technical advancements during the Renaissance made it possible to refine their form and composition. The manufacture of pure, colorless glass into optical quality lenses and mirrors gave natural philosophers unparalleled views of vast celestial mechanics, and the first glimpses into the minute intricacies of the human machine. Likewise, ever-increasing metallurgic expertise and the improved extraction and refinement of base metals allowed for brass alloys to be customized to specific scientific applications. These brass formulae, often proprietary and closely guarded, combined the malleability and conductivity of copper, the brilliant hardness and corrosion resistance of zinc, the workability and low melting temperature of tin and lead, and the strength of iron and nickel.

The ability to cast and machine these refined brass alloys made them indispensable to the creation of precise, specialized tools for many of the rapidly developing fields of scientific inquiry. No doubt, a wide variety of objects outside the realm of science were also improved and made more available during the Enlightenment era because of brass, including eyeglasses, retractable pens and pencils, and domestic lighting fixtures, to name just a few. But scientific instruments of glass and brass are most readily associated with the wonder of scientific discovery during that time period. Glass captured and made observable the matter of the universe—also, significantly, space empty of matter—and brass allowed that matter to be measured and manipulated with accuracy. The ingenuity of these devices of Enlightenment science, combined with their beautifully complex geometries and reflective luster, are what make them rare and treasured objects today, 300 years after their invention. From bell jars and vacuum pumps to electrostatic generators, from microscopes to celestial globes and armillary spheres, few things so

readily elicit admiration, curiosity, and a sense of wonder.

I have experienced this deep sense of wonder for the scientific machines of the past ever since I was young. I grew up playing with gyroscopes, pendulums, and clockwork toys, experimenting with steam engines, and ordering prisms and lenses from Edmund Scientific catalog, as well as my own Wimshurst Electrostatic Generator. I do believe that, for many of the captivating scientific artifacts that emerged from the Enlightenment, their appeal grows with an understanding of what they were designed to accomplish. Part of the reason I still find them wonderful after having studied and admired them for years is that they are constant reminders of not only the marvels of the cosmos itself, but of the human ingenuity that made such huge leaps in understanding with such rudimentary technology.

The other reason that I find the equipment of 17<sup>th</sup> and 18<sup>th</sup> century science so captivating, and the reason I believe it has such a near-universal aesthetic appeal, is that it engages sensory and problem solving components in the human mind. Human beings are naturally drawn to light; in the case of antique scientific machines, we are attracted to the prismatic distortions of a world glimpsed through layers of glass, and the glints of light that bounce off polished metal. Attracted at first by the visual forms and mesmerizing effect of brass and glass, many viewers then experience a desire to mentally re-construct the machines, a natural curiosity to understand, contextualize, and catalog the purpose of each piece in the mechanical puzzle. And whether or not we are able to discern what the inventors of these apparatus were attempting to discover or prove, their aesthetic impact has the ability to stop us in our tracks and cause us to wonder.

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My intent with *Gauge*, *Core*, *Array*, and *Capacitor* (Figures 7, 8, 9, and 10), is to engage viewers' aesthetic sense of wonder in a similar way. Every brass component is fitted and polished to create visual coherency, adding up to more than the sum of the parts, while consciously alluding to forms and qualities of scientific inventions from the past. I believe strongly in recycling and repurposing existing objects as art materials, both from a general principle of responsible environmental stewardship, and from years of experience with how toxic and wasteful new art materials can be. But I also work very hard to erase any indications of the

previous use or purpose of my recycled elements. I want to draw the viewer in for a closer examination of each apparatus with the same wonder that genuine scientific equipment elicits.

Most often I hunt through rummage sales and thrift stores for objects with symmetries that give an impression of functionality. From a sizable collection of old brass lamps, vintage plumbing hardware, bed knobs, drawer pulls, candlesticks, and discarded electrical elements, and many other brass objects, I combine metal components together into convincingly purposeful mechanical structures. I buy multiples of everyday clear glass objects from consignment stores and yard sales, like votive candle holders, oddly shaped or textured dinner plates, and lighting fixtures and home décor items. Again, arranging multiples in one piece, like the four clear glass towel rods in *Core*, obscures their somewhat mundane origin and lends visual credibility to their use as mechanical components.

Unlike scientific equipment from the past, though, my apparatus ultimately have no purpose, and cannot be understood functionally. This subversion has two goals. First, it pairs imagination with wonder by inviting viewers to participate in giving the artwork meaning. Viewers have to wonder whether my apparatus are antique or modern, and even when that is not entirely clear, I find over and over that people try to assign function to them anyhow. Whereas some actual scientific inventions are visually appealing, but have forms so complicated or impenetrable as to prevent a casual understanding of their purpose, my apparatus beg for viewers, themselves, to imagine their intended uses. Second, especially with upcoming generations in mind, I hope to invigorate their sense of wonder by contrasting modern technology they have available to them, but about which they feel no wonder, with archaic “technology” that excites their sense of wonder, but is ultimately without function.



Figure 7: Gauge



Figure 8: Core



Figure 9: Array

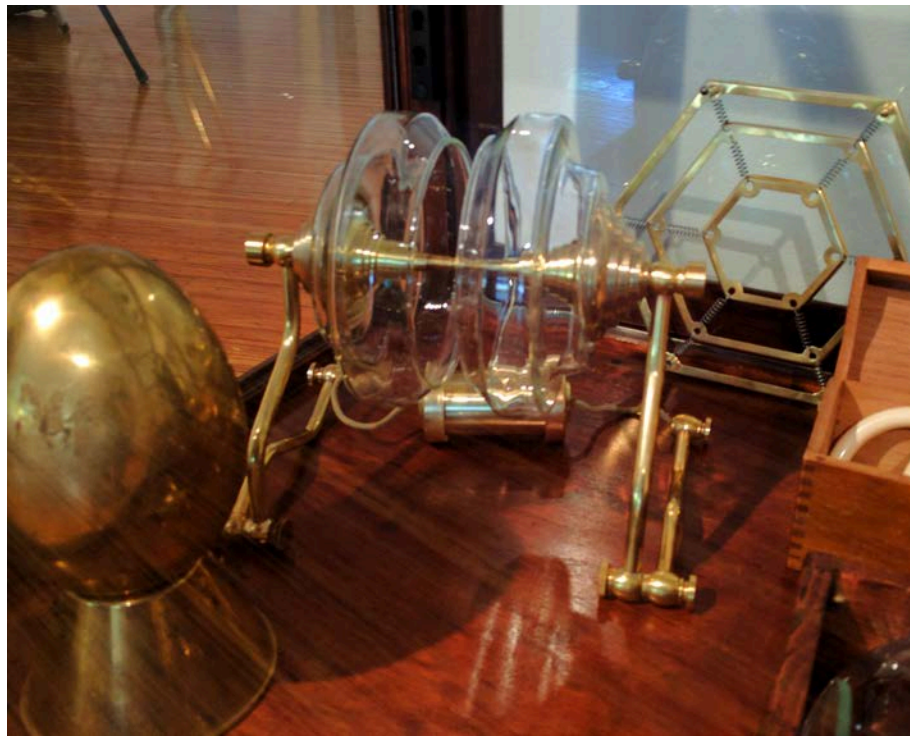


Figure 10: Capacitor

## CHAPTER 4: COLLECTING WONDER

*To see a World in a Grain of Sand  
And a Heaven in a Wild Flower  
Hold Infinity in the palm of your hand  
And Eternity in an hour  
—William Blake*

I would wager that there is a higher percentage of “hoarders” among artists and other creative types than in society at large. Looking at my own penchant for finding and stashing what might seem like random, often impractical objects, I’ve come to realize that at least two driving motives compel my habit of collecting used brass and glass. I imagine these two reasons for collecting are common to many artists, and for me they are deeply emotional; they are as emotional as my connection to art, itself. I collect things which I find beautiful. And I collect things with which I intend to create beauty.

To be clear, I fully accept and appreciate that compelling art does not always fit into the conventional definition of beauty. The notion of beauty is an intellectual moving target, in any case, with changing value and sensibilities across eras and cultures. My emphasis on beauty and the high value which I assign to it are in no way meant to exclude or devalue work that is more conceptually powerful than it is aesthetically pleasing. With that in mind, it might be more accurate to replace the words “beautiful” and “beauty,” as I used them above, with “wondrous” and “wonder.” That is, I collect things which I find wondrous. And I collect things with which I intend to evoke wonder.

What is it about the particular objects I collect that makes them wondrous? How do I recognize certain discarded or undervalued items as raw materials for my own art? The soul or character of the various things I collect is difficult to narrow down, other than a material construction of brass or glass. As mentioned previously, I am drawn to certain contours and symmetries—circles and spheres in particular—and objects of indeterminate style, origin, and

time period. But more often than not, it is the quality and attention to detail in any given thing that makes it beautiful to me. The artistry in its rendering, evident in form and function, excites my sense of wonder.

I am powerfully drawn to self-contained systems, subtle machinery and elegant design, and items which occupy a place of such perfect sense and purpose, it is hard to imagine that they were created, that they have not always simply existed. Simultaneously, I find beauty in potential, in the elements of a system that may have broken down, and how those objects might be reassembled in a new expression of beauty. In fact, the wonder they elicit is partly bound up in the reconsideration of their familiar forms in unfamiliar combinations. Everyday consumables, outmoded or exhausted and then discarded, stand alongside once precious and more conventionally beautiful objects in my collections. A single pendant crystal can have more potential, more wonder in its facets, than the entire chandelier. For example, in *Aurora*, glass rods from an out-of-fashion, discarded chandelier were frosted, fitted in brass hoops, and reimagined as an 18<sup>th</sup> century model of the *aurora borealis*, or “northern lights.” (Figure 11)



Figure 11: Aurora



## CHAPTER 5: ART, SCIENCE, &amp; WONDER

*Two things fill the mind  
with ever increasing wonder and awe...  
the starry heaven above me and the moral law within me.*  
—Immanuel Kant

Wonder is an irrepressible emotion, much like fear; that is, wonder is a primal, reactive state rather than a calculated, anticipatory one. Wonder is perhaps one of the most archetypal emotions, along with fear, because of its phenomenological relationship with sensation and discovery, both within the self, and without. Every new object, concept, and circumstance we encounter, physical or abstract, enters our consciousness as an unknown, which the evolutionary physiology of our brains treats, to some degree, with the emotion of fear or wonder. Nonetheless, it does incorporate the faculty of reason, and can be cultivated as a unique and persistent attitude toward new sensory input or information, often referred to as a “sense of wonder.”

In an article written for *Art Practical*, entitled “Art + Science = Magic (Or Not?),” artist and BAASICS cofounder Christopher Reiger presents a Venn diagram of Stephen Jay Gould’s non-overlapping “magisteria,” namely science and religion, with two more overlapping magisteria, art and philosophy. (Figure 12) But Reiger leaves the overlapping sets ambiguously shaded and unlabeled. I believe a few simple, yet significant amendment to the diagram clarify just how foundational wonder is to the way we process all other experience, and how it takes on unique aspects and leads to different emotional and intellectual trajectories, based on the magisteria in which it is encountered. (Figure 13) Where the magisteria of science and art overlap, at least in the light of modern scientific illumination, a space is created in which wonder can develop into admiration of reality and enthusiasm for learning. That specific kind of admiration is what made the *wunderkammern* of the 17th and 18th centuries so popular, and what I hope to tap into with my own work.

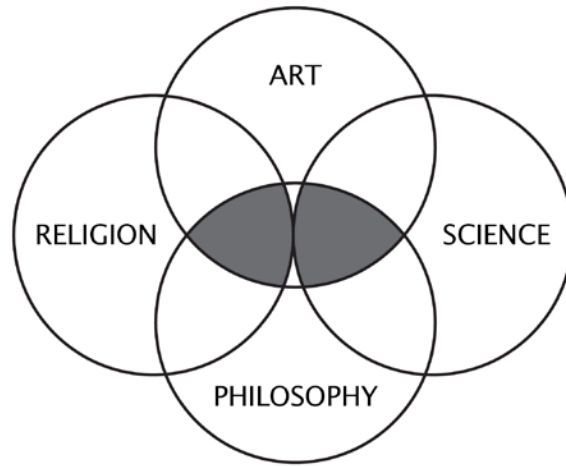
As with other human activity, millennia of evolution have embedded a biological feedback

for wonder into the chemistry of the brain. Like other experiences which we find pleasurable and rewarding—good food, sex, gambling, solving puzzles, etc.—wonder excites regions of our brain responsible for the release of reinforcing neurotransmitters and the storage of emotional memory. Even the *anticipation* of a wondrous experience begins a chemical cascade in the brain designed to embed that experience deeply in our long term memory, complete with the recollection of the associated pleasant emotion. This means that, while we can only experience wonder at an unknown thing once, we can enjoy the positive emotion of that wonder as long as the memory of the encounter persists.

The phenomenological connection wonder has with the five physical senses is substantial, too, and is perhaps most easily identifiable with vision. In several languages the word for wonder is etymologically related to the concept of vision, such as *miraculum* in Latin—the origin of our English words miracle, marvel, and admire—and *thaumazein* (θαυμάζειν) in Ancient Greek, not to mention more loosely associated synonyms, like fantastic and spectacular. The sensory connection that wonder has with sight is of particular interest to me as an artist, and its visual-emotional-intellectual mechanism of action greatly affects what information we acquire, and how we acquire and process it.

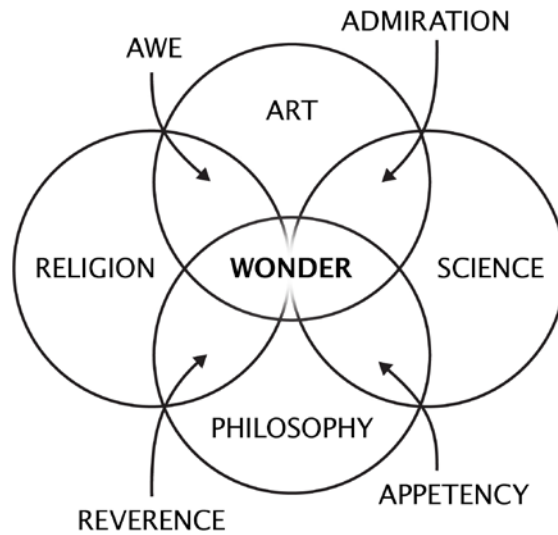
In teaching art and design, I rely heavily on the interconnectedness of art, science, and wonder. Or to be more specific, I use the brilliant interactions of art and science to prime my students for an experience with wonder, with the goal of letting that wonder energize their learning and positively fix my instruction in their minds. And the interconnectedness of art, science, and wonder goes much deeper and farther back in time than my successful moments in front of the class. As discussed in the first few chapters, it is only because of science that I am able to use wonder as a didactic tool in art education. The information I share that elicits wonder in today's students is pleasurable to them because science has demystified and dignified wonder over information that society didn't always understand, and often feared. Or in other words, it is because of the positive experience with wonder that I hope to permanently impress important art and design principles upon students, but it is only because the understanding of science has made wonder into a knowable and enjoyable sensation.

The benefits of the collaboration between art and science are mutual. Science makes wonder in the art room a positive teaching device, and lends new, exciting, and stunningly beautiful imagery and graphic tools to the artist's palette. But art, in turn, is a way to make science understandable and approachable to broad audiences, creating visual delight and wonder using data that would otherwise be incomprehensible to average consumers. Fascinating subject material and intellectual gravitas are exchanged for beautiful representation and greater public appreciation. The three concepts—art, science, and wonder—come together seamlessly and beautifully in the classroom, and I combine them almost every day in front of my classes, to reawaken the intellectual, creative, and excited side of this upcoming generation of students.



### THE FOUR MAGISTERIUM

Figure 12: The Four Magisteria, Christopher Reiger



### THE FOUR MAGISTERIUM

Figure 13: The Four Magisteria, Amended Amendments, Joshua Kirby

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