Magic is Only Magic Until it is Science; Unifying Art/Science Pedagogy for Sustainability

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complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract for Masters

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Sabina Rock

As educators it is part of our job to ensure the long-term best interest of our students. At this point in our history, it is common knowledge that the number one threat to the futures of students is climate change. It is therefore imperative to adjust our teaching methods accordingly by engaging in more sustainable, accessible, cross-disciplinary practices to address this concern.

It is also common knowledge that, for several hundred years now, the fields of the arts and the sciences have been considered as separate from each other; this despite the fact that the two fields were once indistinguishable. Isaac Asimov writes that, by the 1800s, the exponential nature of scientific discovery made it impossible for one person to master all the sciences and that, "… with each generation of scientists, specialization has grown more and more intense" (Asimov, 1985, p.138). This, he goes on to say, renders scientists as "magicians – feared rather than admired" in the eyes of those who have studied other topics (Asimov, 1985, p. 138). He also writes that one of the most integral components of scientific advancement is the ability for scientists to better communicate: this is a double-edged sword in the age of Facebook. The specialization/mystification of science combined with an abundance of social media has left us with an issue: those who do not choose to study the sciences specifically are taught very little science. The result of this has become an internet hailstorm of false information amongst a well-meaning public that simply struggles to tell good science from bad. Mercifully, the solution is simply to make scientific concepts more palatable for those who may not possess a particularly scientific mind. After all, an individual may easily understand scientific concepts without actually being a scientist by profession. Isaac Asimov words the same notion slightly differently, stating that a person does not necessarily need to be able to *write* a symphony to enjoy *hearing* one (Asimov, 1985). Either way, the sentiment is the same.

Over the past year and a half, I plunged into a studio thesis process which addressed the question: how can I bring both scientific precision and sustainability into my visual arts practice and how might this inform art education practices? I researched ways we can bring scientific precision into more visual arts projects. To do this I began by using Steiner and Kolb's philosophies, along with the scientific method, and embarked upon a research-creation thesis that explored the above-mentioned questions. The result of my research has been this paper, and a documentary of the same name.

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This page is dedicated to thanking the professional colleagues and people who have given me the most support during my graduate work.

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I would like to thank my supervisor for guiding me through this process, and my family and friends for their unwavering support.

Thank you to all.

Dedication

Dedicated to the memory of my Dad, who somehow managed to carry me through this entire thesis in spite of the fact that he passed away six weeks before it started.

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Chapter 1: Introduction

1.1 Introduction.

As educators it is part of our job to ensure the long-term best interest of our students. At this point in our history, it is common knowledge that the number one threat to the futures of students is climate change. It is therefore imperative to adjust our teaching methods accordingly by engaging in more sustainable, accessible, cross-disciplinary practices to address this concern.

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[1] As of April 2024 the documentary is available through Spectrum and on Youtube at https://www.youtube.com/watch?v=Rld6XPUuLuU

1.2 Positionality.

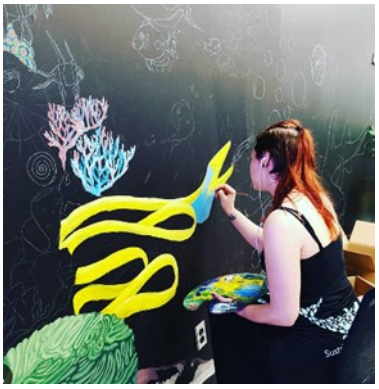

Figure 1. Myself, painting Reef Wholesale's custom mural.

I happen to have an accidentally specialized background in both the arts and the sciences combined, with about equal experience in each. It is for this reason that I believe I possess the specific knowledge required to research and opine on the articulations of both within the context of my work. During my extended undergraduate career, I passed all but two pre-med courses before admitting to myself that I would rather re-start my entire career than re-take calculus. From there I switched back into fine arts and graduated with a studio degree. This left me with equal appreciation and understanding of both art and science.

In 2015, while still pursuing my undergraduate degree, I was lucky to land an interview at Reef Wholesale International and, though I didn't have any degree yet per se, they determined that my extant knowledge was sufficient enough for a position as a technical biologist. This sounds very impressive, but in reality I spent my first several weeks feeding fish, spraying out filter canisters, and scraping algae off tanks. I learned quickly and, over the years, I have worked in every slot our facility has (excluding the office). I have also worked with almost every sort of marine animal that can be legally imported, particularly corals. My specialization is "fragging" – short for "fragmenting" of corals. Fragging requires one to identify the coral species, assess its level of health, break it down into several smaller pieces (without causing undue skeletal or tissue damage), then re-mount the cut pieces on to small concrete plugs, which are generally between a centimeter and an inch in diameter. From there, they require a clean environment with high water flow to ensure that the cut edges heal quickly; corals are, after all, animals. Fragging is extremely important because hundreds or even thousands of new corals can come from a single captive specimen, helping to minimize strain on wild populations. In addition, frags are the best way to test the effects of changing water conditions for various coral species in a controlled environment. Frags are also used to actively replenish wild coral populations; think of the saplings in a reforestation project and the concept is the same. Though they were not projects I was personally involved with, Reef Wholesale also worked with the marine lab at the University of Guelph as well as with Ripley's Aquarium in Toronto. I took a hiatus between 2020 and 2023 to pursue this thesis in Montreal, but am proud to say that I am currently back again

Figure 2. Myself at Reef Wholesale, holding an unusually friendly, orange, warty frogfish.

Figure 3. A macro photo I took of a chalice coral.

and fragging. In my time there I have been able to witness the drastic changes to marine life in merely nine years of climate change. This effect was only compounded by my hiatus, as the contrast between the “then” and “now” was quite noticeable in the size and variety of animal arriving.

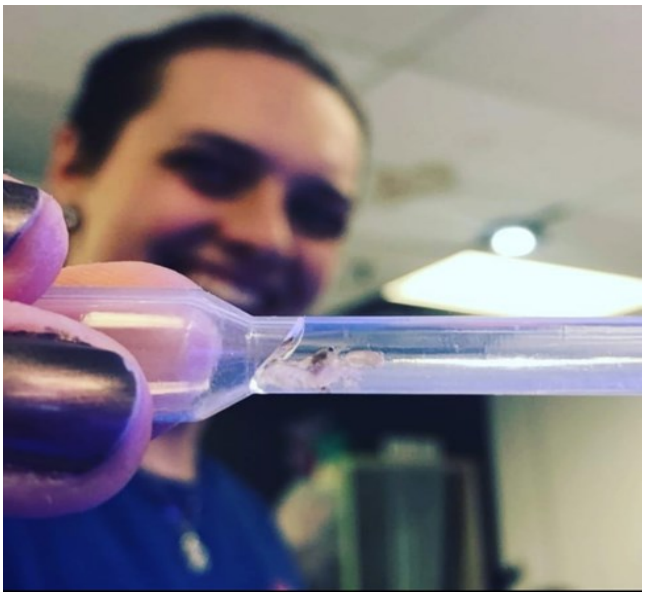

Figure 4. Myself at Reef Wholesale, about to pair a rare and expensive pistol shrimp with an equally rare and expensive goby (they do this in the wild).

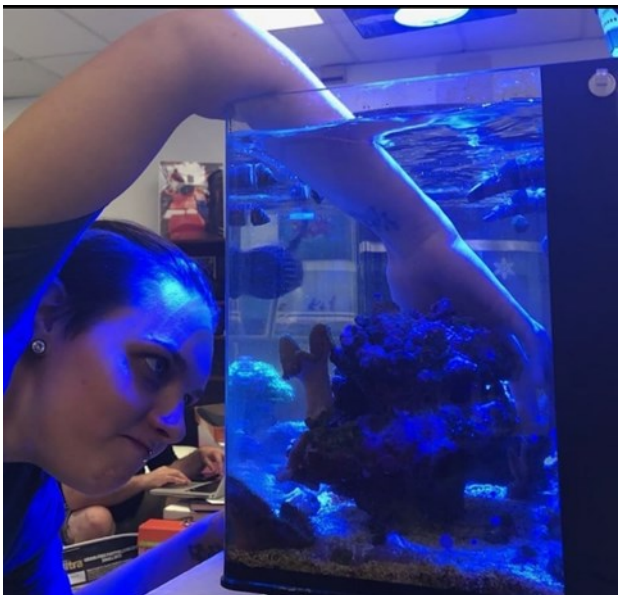

Figure 5. Myself, shortly after Figure 4, attempting to rescue the same rare shrimp from the same rare goby due to irreconcilable differences.

In 2016 I registered as my own LLC and became an independent contractor for Paint and Cocktails, teaching Bob-Ross-style paintings to groups of adults. This led me to form Community Canvas, a non-profit program that raised funds for the Parry Sound Resource Center for Independent Living and offered a therapeutic painting activity to both members of the program and art-loving locals alike. At a Community Canvas event I was introduced to Gayle Dempsey of the Muskoka Chautauqua, who then hired me as both a summer event coordinator and artist in residence. I held the same positions for two summers but was unable to take on a third due to covid and my relocation to Montreal.

I’ve often heard it suggested that my studio/biology seven-year-long mashup of a bachelor’s degree was akin to living a double life, but I do not feel it is that way. Regardless of my activity I inexorably found art in science: a frag is a tiny sculpture as much as it is a living specimen. This thesis is the culmination of that. I do not claim to be an expert in either the arts or the sciences, but I do have the skills required to be considered an expert on the articulation between the two.

1.3 Previous studies.

While attending York University I took two classes with Dr. Leslie Korrick titled *Cabinets of Curiosities* and *Leonardo da Vinci: Man of art and Science* respectively. *Cabinets* was relatively straightforward in its concept and, more or less, examined a detailed history of the museum with a particular focus on the era before the separation and specialization of the institutions into categories such as natural history, human history, and fine art. We examined the beginnings of small, private *wunderkammern* which only grew in popularity until Charles Wilson Peale opened the first "real" museum; The Philadelphia Museum. Interestingly, it is now known as the Pennsylvania Academy of the Fine Arts and it holds the title of America's oldest art school as well as first museum. *Leonardo* focused deeply on the articulations between art and science. Much of the course involved readings from *Leonardo*: a journal published by the MIT Press. The journal was founded in 1968 by Frank Malina (a kinetic artist and "astronautical pioneer"). According to the *Leonardo* website, the journal was created "…to serve as an international channel of communication among artists, with emphasis on the writings of artists who use science and developing technologies in their work" (Leonardo.info).

Figure 6. My "foolproof" turmeric dye on a cotton yarn purse rendered in nalbinding.

Within the year previous to my thesis proposal submission, I performed several preliminary dye experiments to test myself for this intended research. I learned that I intuitively produce artistic work with a scientific frame of mind and am able to successfully translate my artists practice into reliable, replicable, scientific execution. As well, I now also have the experience required to successfully create new dye experiments based off of past work. For example, I engineered a foolproof bright yellow formula that dyes both plant and animal fibers beautifully and thoroughly, yet can also be modified via the use of different mordants.

I further went on to experiment with the effects of different mordants using cochineal beetles gifted to me by Dr. Leslie Korrick in her *Leonardo* class. I was able to successfully repeat the process exactly three times, with only the mordants differing, and ended up with three different shades. I was also able to engineer a prototype "colour changing" dye made with red cabbage, but was unable to get any reasonable colourfastness, which forced me to temporarily shelve the cabbage dye. Thanks to these preliminary experiments I already had a reasonable framework upon which I built

my research, and I referred directly back to my previous dye formulations when I was processing the wool.

Figure 7. A processing vat of basic cochineal dye.

Figure 8. A processing vat of neutral cochineal dye.

Figure 9. A processing vat of acidic cochineal dye.

Chapter 2: Underpinning and rationale.

In this section I will be describing the two major educational theories that underpin my research into science-art. Both Steiner and Kolb are currently used in Waldorf schools as hands-on learning methods.

2.1 Steiner

Rudolph Steiner is the best example of an artist/scientist within the context of art education. His work paved the way for art-science pedagogy and spawned Waldorf Schools; which we will re-address in the literature review. Steiner's holistic method puts emphasis on child development through the use of both real work and play in a natural environment (Halgraves, 2020). It has been found empirically that Waldorf students have greater levels of artistic skill, social interest and identification, self-esteem, and empathy. Students also have on average a higher rate of post-secondary attendance (Halgraves, 2020).

One major criticism of Steiner is that his work occasionally merges into the realms of pseudoscience, particularly that which involves his "spiritual science". Steiner himself, however, fully acknowledges that his methods are not applicable in specialized hard science settings, like hospitals or laboratories (Steiner, 1914, transcribed from lecture and translated from original German). He further described his interpretation of faith-based science beliefs as this: "a truly religious person can grasp that religion is only enriched and deepened by scientific knowledge… Mankind has matured; the time for prophets and founding religions is over" (Steiner, 1914, transcribed from lecture and translated from original German). It is therefore within precedent to adjust his methods in accordance with the most up-to-date knowledge available, while still utilizing the framework of his methods.

2.2 Kolb

Asimov writes that an essential principle of science is the ability for scientists to communicate with each other and share data (Asimov, 1985, p. 136). This means that it is necessary to begin focusing teaching efforts into distance programs that allow for more accessible global learning. In 2005, Richmond and Cummings wrote a paper which suggests using Kolb's theory as a basis for online distance education. This sets the precedent for using Kolb's theory in my research because creation of a more sustainable,

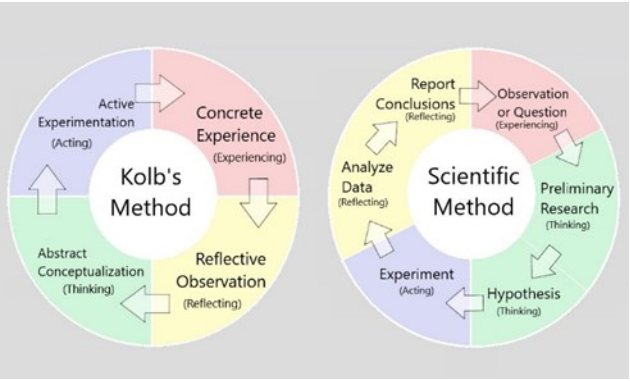

Figure 10. Kolb's method visualized beside the scientific method.

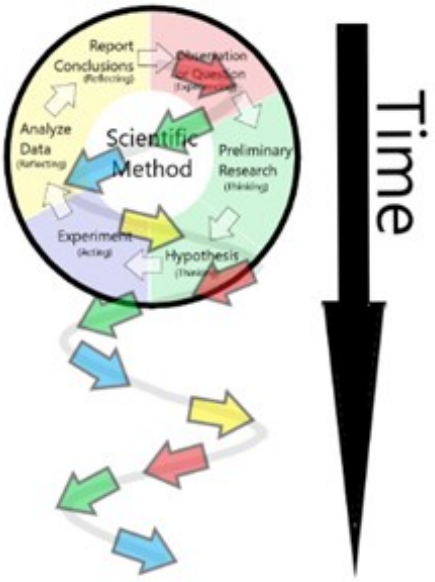

Figure 11. A helical model of the scientific process over time.

accessible pedagogy requires that distance education be an option for students in remote or otherwise inaccessible areas.

The scientific method is comprised of several different steps and actions that are used by scientists world-wide across various disciplines. Kolb's method, which is derived from Steiner, is the closest procedural match to the scientific method because both Kolb's method and the Scientific method share the same general steps. These include, in no specific order: experiencing a phenomenon, reflecting on the phenomenon, acting towards some end, and then thinking about potential implications going forward. I've selected Kolb for the comparison because of the immediately apparent similarities, which I have illustrated here.

Figure 12. The double helix model formed by the interaction of Kolb's and the Scientific method as they occur through time.

The above mentioned steps take place across time as they complete their cycles; leaving us with a helical 3D model of the process as a whole (Figure 12). In an article for the journal *Leonardo* titled *The Interaction of Art and Science*, Sheldon Richmond states that "…art and science form a functionally interdependent relationship." (Richmond, 1984, p.82). My above chart backs this up visually. If we place both helical models beside each other we are left with this double helix model (Figure 12) that shows the relationship.

2.3 Science/Art

There is a plethora of material available about the interactions between art and science. Hundreds, if not thousands, of articles have been written on the benefits of hands-on science education in the STEM and STEAM fields. The intermingling of science and art is seen so often that, in 1968, MIT launched the previously mentioned magazine; *Leonardo*. As of October 2022, the journal is currently in it's 55th edition, all to illustrate the connections between the two. Eisner writes about the folly of segregated learning fields, "Put simply, the arts have no monopoly on art. There is art in science just as surely as there is art in art" (Eisner, 1995, p.1). Last year Routledge produced a textbook titled *The Routledge Handbook of Art, Science, and Technology Studies* which, according to its abstract,

"provides scholars and practitioners already familiar with the themes and tensions of science-art with a means of connecting across disciplines" (Rogers et al., 2021, p. 1).

This pattern is also seen outside of pure academic circles. *Art the Science* is a Canadian non-profit organization that, according to their website, is committed to "facilitating artist residences in scientific research laboratories across Canada" as well as chronicling "science-art and its cutting edge creators in Canada and around the world", and facilitating "cross-disciplinary relationships between artists and scientists with the goal of fostering Canadian science-art culture" (About Art the Science, 2022, paras. 1).

2.4 Scientists who use art.

The development of the science-art field was initially pioneered by individuals such as Beatrix Potter; an English conservationist and natural scientist who revolutionised children's literature with her storybooks, and Santiago Ramon y Cajal; a neurosurgeon who revolutionized medicine with his detailed illustrations of the brain. They and others like them breached the modes of conventional knowledge for the time in order to create new knowledge streams. For example, Potter's love of natural history combined with her artistic talent allowed for the creation of some of the best children's literature of all time, complete with beautiful and accurate (though fanciful) representations of English wildlife in the early twentieth century. In a similar way Ramon y Cajal was the first person to begin mapping the workings of the human brain. Technically, all modern neuroimaging can be traced back to his decision to make an art project out of his scientific knowledge.

The archetype of scientist/artist is not one that is relegated merely to the past, nor is it tied strictly to bookish media. Lauren Bowker is a designer and inventor who specializes in material science. She is the creative director of *THEUNSEEN*, a research and development initiative that uses colour-changing fabric (intelligent materials) to visualize data. Her recent work also branches into her own cosmetic line, as well as a partnership with Schwarzkopf aimed to design sustainable and colour-changing hair dye (TEDx Talks, 2017).

2.5 Artists who use science.

In the same vein as scientists who use art, there are perhaps an even greater number of artists and art institutes who utilize science in their arts practices. This is further compounded upon when we add the element of fiber arts. For example, Christine and Margaret Werthrim's *Crochet Coral Reef Project* describes itself on its website as "a nexus of art, science, mathematics, environmentalism, and community practice" (Institute for Figuring, 2022). The project collectively does exactly what one would think; various artists work together to crochet very realistic coral reefs with the intention of raising awareness for ocean protection. This is fitting because the textile industry is the number one threat to the world's oceans due to microplastics, which kill more than 300,000 sea animals alone each year (Musau, 2017). Woolmark, an organization promoting sustainable textile, puts it in a very direct way with their slogan; "wear wool, not fossil fuel".

Still there are others who work with differing materials towards the same end. For example, Chiara Vigo, the "last weaver of sea silk", is an intergenerational artisan turned

environmentalist. Under “strict supervision” from Sardinian wildlife officials, she dives for and collects hair-like byssus filaments from salt water molluscs, with which she then spins and weaves (Great Big Story, 2022). The molluscs are not harmed during this process and are released back into the wild, living to produce more sea silk in the future (Paradiso, 2015). The idea of weaving with non-standard materials for conservation purposes also has implications in Canada. Alayna Rasile-Digrindakis is an artist and conservationist who works primarily with milkweed. In late summer she collects and spins milkweed floss from the seed pod fluff (TEDx, 2019). This is extremely important research because, as I learned growing up in rural Ontario and reinforced with a second-grade project in which my class raised monarchs, milkweed is the only food source for the monarch caterpillar. In 2022, monarchs were added to the endangered species list (World Wildlife Fund, 2022, Table 1). Milkweed is also best known for growing in places such as road-sides, which means that many municipal road crews cut it back. In fact, this planned culling of milkweed within my home municipality is one of the reasons I chose wool for my thesis; it just wasn’t possible to collect a usable amount of milkweed. Luckily we have a remedy for environmental issues like this; education and exposure.

2.6 Waldorf

Waldorf schools are designed with this exposure in mind; they emphasize hands-on research and real life experiences**.** There currently more than 1090 Waldorf/Steiner schools currently in 64 countries, 16 of which are associated with the UNESCO Associated Schools Project Network. There are also more than 1857 Waldorf Kindergartens across 70 countries. “They integrate the arts in all academic disciplines for children from preschool through twelfth grade to enhance and enrich learning.” (Waldorfeducation.org). Steiner was kind enough to inject art into the sciences, I have now completed the helix by injecting science into the arts.

2.7 Art

Steiner and Kolb both write about hands-on learning that defies traditional, dry, classroom settings. This works because I did hands-on research by working with a fleece in a traditional fine craft artform. I have used cross-disciplinary methodologies across my whole process, so all of my dyes have an artistic title along with a code for a more detailed and comprehensive method of data organization.

2.8 Science

Waldorf Education as well as STEM/STEAM teaches science through hands-on, integrated methods designed with inclusivity in mind. This, however, is slightly limited in its scope thus far. For example, Eunhyung Chung from the Rhode Island School of Design wrote an arts-based science thesis titled *When Art Education Meets Environmental Issues*. In this work, she cites an example project titled *Shake & Change to Save a Koala*. In the project, the viewer would shake an ash globe in an attempt to change the colour from red to green while reading facts about koalas. This is a metaphor for the action that we all must take to prevent climate change, through the imagery of the noble koala (Chung, 2021, p.47-53). Though projects such as this are scientific, artistic, and educational, they do not quite get to the crux of true sustainability. This is because only one person (Chung) engages in the act of creating, and the object created

serves no purpose other than making a point about Australian bush fires. Once that context has been used up, the sculpture becomes another useless object. It is for this reason that I embarked on my research creation journey in search of an art object that has a use past the experience of its creation.

Chapter 3: Methodology

3.1 Research for Creation

Research for creation is a cross-disciplinary approach which “describes a conglomerate of approaches and activities” and “requires a sustained creative practice” (Chapman & Sawchuck, 2012, p.12). It emphasizes similarities and articulations; I have also done this by combining my research creation process with the experimental method.

3.2 Experimental Research

Experimental research allows for scientists to measure the relationship between variables. By manipulating the independent variable, one is able to measure the effect on the dependant variable (Blair, 2016). My dye work included dependant/ independent variables as well as a control and a hypothesis. I formulated my hypotheses like so: “if I combine these dye ingredients in this way, it should yield this colour result”, or “if I modify my current dye recipe in this way, it should yield this colour to this degree”. My dependant variable was the final colour result. The independent variable can be any specific component of the dye recipe. The controls were both the intended colour; to asses the success of the dye, and the untreated fleece; to illustrate the degree of colour change. In addition, I ensured—to the best of my ability—thatraw, organic cotton, linen, milkweed, or hemp without undergoing some rather extreme travel and/or shipping. I could, however, easily obtain a local fleece. I had worked with various yarn types but I had only had experience with loose, wool fiber due to some training in wet-felting prior to this project. Though I didn’t felt anything during this process, it still made the most sense to use a fiber I was more familiar with in order for me to collect the best data.

3.5 Data

The data consists of notes, summarized in a similar way to Melissa Ledo’s “Best Practice” section, photos, videos, notes of the process, and the finished yarn. I organized my data tidbits by type into stationary media (notes and photos) and nonstationary media (video and audio). The reasoning for the varied media is to make the project accessible to as many people as possible; the information in this literary piece is the same as the information in my documentary and it is up to the individual to decide if their preference is text or video. While

the chemical integrity of my supplies was respected. This simply means that I made my own mordant and dye baths from scratch, then used them on fiber that I processed myself.

3.3 Specified Methodology

I sourced a whole fleece from a local farm and documented the process of breaking it down and transforming it into a hand dyed, hand-spun textile project. I used Claire Boley's 2011 work *Hand Spinning & Natural Dyeing* as my primary instruction manual during this process.

3.4 Procedures

I organized the larger research experience in to a series of smaller, individual experimental phases that honored the central concepts of Kolb's theory and the scientific method. The general flow was as follows.

a. Met the sheep and select a fleece
b. Washed the fleece
c. Combed and carded the wool
d. Dyed the batts
e. Spun the Yarn
f. Reflected and wrote on the entire process as a whole

I selected wool as the fiber for this project because it was the most environmentally friendly source in my case. Due to my location, it wasn't reasonable for me to obtain a large quantity of

analyzing my data I searched for articulations, tensions, and surprises to answer my research question.

3.6 Research Question

How can I bring both scientific precision and sustainability into my visual arts practice? How might this inform art education practices?

Chapter 4: the fleecening.

4.1 Obtaining a fleece.e

My search for a fleece began with a search for a sheep. Though I did grow up rurally, it was largely spent between cow country peppered with horses, and the Muskoka bush. Though sheep and goats were sometimes kept, it was almost universally as family pets and 4H projects. This is echoed by the fact that, as of January 2024, Ontariosheep.org has listed only one wool farm in Muskoka. It is logical, though, that Muskoka would not necessarily produce ideal grazing conditions due to its location on the bedrock of the Canadian Shield. The lack of sheep, however, magically does not seem to impact the appreciation of wool in my hometown. During my research for this thesis, I was delighted to learn that there are only a handful of wool mills in Canada, and one of them (Wave Fiber Mill) is located in Parry Sound. My search for a fleece did not begin at *Wave* though; I was, after all, looking for a single-source raw fleece to process myself and for that I needed a sheep.

My search for said sheep began with the Muskoka Fiber Arts Festival in Bracebridge Ontario – an area I was familiar with due to my work with the Muskoka Chautauqua. Held in the barn of the fairgrounds and catered by the local funnel cake vendor, I spent the afternoon wandering amongst rows of immaculately quaffed fiber bundles sourced from a collective number of species that could put a natural history museum to shame. I purchased a bundle of black angora rabbit fur accented with dyed blue fibers and tinsel, learning in the process that small-batch angora is the cutest extant method of fiber collection. The process is simple: one places the rabbit in front of a large pile of their preferred food, then uses either a small pair of scissors or a skilled pair of hands to delicately remove individual tufts of fur while the rabbit enjoys a bottomless salad. I would like to note at this point that, in the fiber community, “fiber addiction” is commonly joked about to describe the irrational longing for strings and things felt by many of us. Like many communal jokes we make of ourselves, however, there is a sliver of self-awareness. For example, following my discovery of the angora collection method, I was emotionally fully prepared to abandon the fleece and procure an entire hutch of rabbits, undaunted by the fact that I am violently allergic to them. Such is the passion of a crazy yarn lady.

I finished socializing and left the rabbit related area to peruse a selection of spindle starter kits when I was approached by a man.

“Excuse me,” he said, “I don’t mean to interrupt, but I overheard you were looking for a fleece?” I replied that I was and he continued, “Oh well then you need to call Leslie over at Crow Hill – she’ll have a few you can choose from for sure. Hang on, I might have a card”. Reaching in to a well-used folder and rifling around for a minute, he produced a business card titled Crow Hill CORRIEDALES, complete with a line drawing of a Corriedale sheep. I thanked him and he excused himself back to tending his booth while I continued spindle shopping,

eventually selecting two. As I was paying for them the woman ringing me up inquired about my interest in learning to spin and I revealed that I intended to process a whole fleece.

"A *whole* fleece?" She replied, "Have you talked Leslie over at Crow Hill? If you want a whole fleece she's the person you need". In that moment I knew I was on the right track.

Figure 13. A very good dog watching over her flock.

Leslie and her husband Craig own and operate their farm in Cameron, Ontario. They produce breeding stock, fleece, and lamb as a necessary byproduct of the livestock breeding program. The morning I arrived was bright, with massive cumulus clouds drifting lazily in the clear sky. Though the round trip totalled about five hours in a hybrid vehicle, it was a perfect day for traveling. When I arrived to the Rancher's Road property I passed through an opaque thicket of brush and in to, what I can only describe as, precisely what I hoped a small wool farm would look like. Though it was very hot that day, the pastures were still a verdant green with a handful of sheep dozing in the shade provided by purpose-built shelters. I parked next to an apple tree, branches heavy with half-mature fruits, and relished in standing after the long drive. A door opened in the red brick house and a black shape erupted from within, followed by a waving Leslie. The shape hurling towards me turned out to be a short-haired boarder collie, who crossed the gap of the yard in about two seconds before commencing on a very thorough examination of both myself and my vehicle. She was not aggressive in the slightest, just confident, thorough, and quick in her processes. She sniffed around the entire perimeter, my purse, my shoes, my legs, and for an instant even nosed the palm of my hand. It felt a little like going through airport security, but in one-fiftieth of the time and with a much friendlier agent. She was (and as far as I'm aware, still is) a wonderfully good dog.

Leslie was clad in blue jeans, barn boots, and a baseball cap that had seen its fair share of sunny days, and I noticed it matched her bright eyes. Her complexion held the warm glow that comes only from a life lived outdoors, making her wide smile appear even brighter. I immediately realized that I had opted for running shoes over my own barn boots and, for a few moments, was deeply ashamed of myself.

"Ready for the tour?" she asked. I nodded eagerly and followed her in the direction of the barn, the collie lightly herding us as we went.

En route to the barn we paused to transfer some sheep from one of the stockyard fields to the wider pasture. I had expected a more sluggish reaction out of the sheep, but the very second the gate opened all half-dozen of them trotted out, single file, into the pasture. I suppose that I,

very much a “horse girl”, had assumed that sheepdogs were necessary in part because sheep weren’t intelligent enough to move themselves. In fact, most of what I had read seemed to indicate that sheep are more than a few stitches short of a sweater. I was delighted to realize that sheep are smarter than I had given them credit for, then moderately chastised myself for underestimating them in the first place.

Figure 14. Corriedale ewes munching on dandelions in the shade of their barnyard shelter.

Immediately inside the immaculately clean barn sat the feed room, bedecked with several dozen ribbons and nearly as many trophies. That room alone was proof of why the entire community seemed to recommend Crow Hill. The barn itself was an arena setup; one large open area divided by movable fences and gates, as opposed to the permanent stall configuration one would see in an equine facility. The pens themselves held about fifty sheep divided into groups and one llama, with a smattering of assorted chickens milling around. Llamas, alpacas, and donkeys, Leslie explained, are often kept by shepherds as flock guardians. Dogs such as Anatolian shepherds, kuvaz, and commodors are also used for this purpose when appropriate. Livestock guardian dogs are not to be confused with herding dogs such as collies as they both perform different functions. Collies and sheepdogs are used in the herding and movement management of a flock, they work with the shepherd and take commands in order to move sheep. Livestock guardian dogs, however, spend the vast majority of their time within the flock as companions and protectors. Guardian dogs will most often eat and sleep with the sheep, and most are both light-coloured and fluffy to some degree. This is so that they can more easily blend in with the sheep to confuse predators. Livestock guardians will often also often have cropped ears and be fitted with a spiked “coyote collar”. Sheepdogs are typically left unaltered because there is a much lower chance of a sheepdog finding itself in an altercation with a predator when compared to a guardian dog.

Figure 15. Lambs on fresh straw in the shade of the barn.

Moving on from the main barn, Leslie led me to a, much smaller, secondary structure. It was here that she stored the fleece in paper (NEVER plastic) bags. In the same structure was a pen that held three sheep. It was a breeding experiment, Leslie explained. She was cross-breeding Corriedales with other varieties of sheep. I have never had much strength when it comes to

Figure 16. Fred the ram introducing himself, with the shy ewe eyeing me suspiciously from the background.

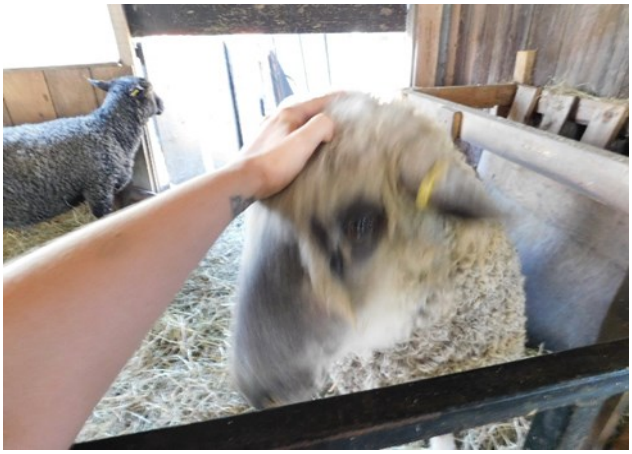

Figure 17. Fred enjoying his scratch.

resisting the urge to pet an animal. Yes, I knew that most sheep probably didn't want to be touched, but I simply had to *try*. I softly reached out a hand to pet the black ewe in the pen, but was rejected both politely and thoroughly. To my absolute delight, however, the initial sheep snub was noticed by the stud ram who came over to me with purpose. He then lifted his head and rested his chin on the bar of the pen, eyeing me expectantly. His request being crystal clear, I obliged him, providing him with a thorough head-scratch. I located what seemed to be a particularly good spot and he closed his eyes, leaning in to my hand. In that moment I learned that sheep can purr. It is not identical to that of a cat, but it is nonetheless unmistakable.

Leslie" I said "I love him – what's his name?"

Oh him?" she responded "that's Fredrick, but we just call him Fred.".

After being formally introduced to Fred, Leslie weighed out my fleece before inviting me in for a cup of tea and a house tour. The house was what I dream of for myself one day; covered in lush potted plants and art from friends and family around the world, preserved full fleeces across the

Figure 18. Fred, clearly smiling and very pleased with the amount of attention he was getting.

couch in colours ranging from creamy white, to red, to gray and everything in between. Leslie regaled me with stories of her trips to Iceland to attend wool workshops and seminars. She also had a library of loose fiber samples from which she is able to pull from for reference at any time.

Figure 19. The first photo of the fleece.

Somehow my visit ended up lasting over three hours, but it certainly didn't feel that long. Every time I tried to leave we would find ourselves getting back into a discussion about one thing or another. Eventually though I did have to make my final departure. So, after several hours and two cups of tea I was ready for the long drive home with my newly acquired fleece.

Figure 20. Part of Leslie's prize fleece collection.

4.2 Picking and skirting

Upon bringing the fleece inside the house pandemonium ensued almost immediately. Both our family dog (Max) and my more adventurous cat (Mozart) gave the fleece bag a cursory sniff, then lost their minds completely. Max, a 90lb rez mutt, is extremely gentle and therefore simply lay down on the floor with his nose in the open end of the bag, huffing the scent like an aromatherapy treatment. Mozart, on the other hand, is a lanky orange-and-white liability with more personality quirks than brain cells. He dove, with all of his might, into the bag like a child into a pile of leaves. He put his whole mind, body, and soul into becoming one with the fleece as he rolled around, shredding the bag in the process. I had never seen anything like it; the bag might as well have been full of catnip. As it turns out, cats absolutely adore the lanolin present in wool. As the project went on, I noticed that every step of the process made Moz less inclined to obsess over the wool. When the fleece was raw I had to store it in a well-ventilated room with a locked door (he sat outside the door and hollered to be let in until I placated him with a consolation prize of catnip). After the first wash, he stopped begging at the door but would still swan-dive into the fleece if given the chance. After the fleece was carded and combed, he left the bag alone but would often steal individual batts if left unwatched. Once the dying and spinning was complete, he lost his obsession with the scent, but began an obsession with stealing the balls of yarn. I was not necessarily expecting to learn first-hand why the old adage of cats and yarn balls is so, but I am thrilled to have the knowledge now.

It took several minutes to untangle Mozart from the fleece, but once I had managed it I brought the whole thing outside to the back porch. I then dumped it out of the bag and on to the outdoor table. This was my first moment really handling the fleece myself and, as I stood there, trying to literally figure out which end was up, one thought replayed itself in my mind: “oh my god, what have I gotten myself into?”. Everything I had read up until that point spoke about a fleece as though handling one was similar to handling any skin or large piece of cloth. So, naturally, I expected unfolding a fleece to be similar to unfolding a saddle pad or hefty blanket. A fleece, in truth, is nothing like a blanket at all. It was like trying to manage a non-newtonian fluid, and unfolding it felt like trying to unfold risen dough; no matter how gentle I tried to be, every movement caught the fleece on itself and tugged this way or that. Each time I folded or unfolded it, the fleecy matrix broke apart and widened the gaps between locks; eventually giving the spread-out fleece a distinctly spider-webish quality. I quickly adapted a “slow and steady” methodology and, with that, it took me about fifteen minutes to open the fleece completely. I then spent the next four hours picking bits of hay, sticks, burrs, mud, and sheep droppings out of the fleece. I would like to note that I did not spend four hours picking the fleece because that is how long it took to remove all the debris. It was like trying to pick all the dust out of an asteroid belt. It crossed my mind that the fleece was regenerating pieces of straw to hinder my progress out of spite for my inexperience. In truth, the next day I put in an additional two hours of picking and decided that the extra hours had not made a notable difference. Therefore, I decided to continue to pick the fleece through the remainder of the project. Luckily, my change in tactics worked and I am now of the opinion that the clean-as-you-go approach is superior. One to two hours was sufficient to remove all of the larger debris, and I would spend that amount of time picking a fleece again in the future.

Figure 21. The fleece, laid out, before picking.

Figure 22. The fleece after picking.

After the initial picking came the skirting. I had been slightly misled by my reading and lulled into a false sense of security by diagrams of non-liquid fleeces with well-defined boarders. I had thought it would, at minimum, be sheep-shaped, but it was largely an amorphous blob. After several moments of consideration and an examination of both sides of the fleece I was sure of

two things: firstly, there were obvious sections of fleece that were stained, short, or wiry, and most likely unsuitable for processing and, secondly, the biggest and brightest locks stuck out notably from the matrix. As the aim of skirting is to remove the dirtiest, lowest-quality wool from the fleece I abandoned the desire to differentiate between the head and tail and simply did a lap around the edge of the fleece, pulling out any questionable wool as I went. After this, the surface area of the spider-webbed fleece had more than doubled, so I elected to divide it into two pieces before beginning the washing process.

4.3 Washing the fleece.

After washing a fleece myself I have come to feel that the term “washing” is somewhat of a misnomer, as it implies more agitation than is required. When washing a fleece, it is imperative to avoid over-agitating the water so the fleece doesn’t felt prematurely. In addition, a fleece requires several rounds of water-only washes before any detergents are added. This made my job easier, as I was able to do the washing outside in a large plastic bin and dump the waste water on the ground. I was only able to do this because there were no additives in my fleece or my water; sheep droppings and mud are not harmful to plant life but sulfates are. There exist organic, non-gmo, non-toxic, sulfite-free, lanolin-based wool “soaps” (which I will discuss in more detail later) that should, theoretically, be alright to dump on the ground. However, I do not encourage this because it is never wise to dump any soap-like products on living ground.

I did a total of three water-only rinses on each fleece half, picking out debris, felted patches, and any scraggly or offcut bits that came up. I let each water bath sit for 45 minutes before draining the tub and gently squeezing most of the water out before refilling the tub with cold water from the garden hose. After the third water-only rinse, I brought each fleece half respectively inside for the final wash. This time I added 5ml of Eucalan to a five gallon bucket before gently agitating the wool and allowing it to soak for an hour before squeezing it out. Eucalan does not need to be rinsed out of fiber, so I laid it out to dry immediately after the final wash. The first fleece half required two nights to dry and the second required only one due to humidity and heat differences. When each half was dry, I balled it up and stored it in a pillow case for transfer back to the city for the remainder of my work. It is best to keep fleece in pillow cases or paper lawn bags because they are breathable. Although it is acceptable to keep a fleece in plastic for a day or two, it is inadvisable to do so long term because moisture trapped by the plastic can cause the fleece to go moldy.

4.4 Carding and Combing

Small towns are wonderful in that word travels fast, and I capitalized on that; within six weeks of word getting out that I needed a drum carder, I had one. I paid 150 dollars for it and anyone who knows carders will know that I got it for a steal. I love it now, though our relationship began on a rather rocky footing. I was deeply insecure about using the carder correctly and

clung to the same “less is more” processing approach from my previous washing. I thought the locks needed a combing before I put them through the carder. However, I was once again bamboozled by the instructions of my predecessors: everything I read or watched told me I could card the locks outright and, though I was skeptical, I attempted it anyways. My thinking was that, if I added fewer steps (like pre-combing) to the processing, I was less likely to make mistakes. It was a disaster. The results came out chunky yet also somehow sparse, and a phenomenal amount of wool ended up on the wrong drum of the carder. I got through one pitiful excuse for a batt and realized I should have trusted my gut. I abandoned my attempt to card raw locks and went in search of a dog brush (as recommended in Clair Boley’s work). To my immeasurable delight, the family dog’s brush was identical to the one pictured in Boley’s

Figure 23. A handful of combed locks with Max's comb.

work. Luckily, Max was happy to lend it to me for the project, and I did return it as soon as I was able.

After my initial failure with the carder, I was even more incentivized to correctly finish the carding. As anticipated, it was much easier to card locks that had already been combed. My second batt was of better construction but was still rather lackluster because I had not pre-combed quite enough. At that point I realized the best course of action was to comb the entirety of the fleece, and then card it. This ultimately saved time by removing the need for me to switch activities between batts. The combing was significantly more labor-intensive than the carding. It also destroyed more than one pair of my pants, left my fingers sore, and bruised the top of my thigh. Could I have combed the locks against a pillow or rolled up towel instead of my own leg? Absolutely. Did it occur to me to do that until I was writing this paper months later? Absolutely not. Ah well, we live and we learn.

The combing process took the better part of six days. It also removed nearly all of the debris that had been missed by the picking and fluffed out each individual lock; this served to more than double the total volume of the fleece. I was reminded of the way sourdough “breaths” as it matures and, at the time, I wondered what the total volume would be when it was spun. As it turned out; the washed fleece took up two pillow cases, the carded fleece took up three pillow cases, the dyed batts occupied a 1x1x1 foot storage box, and the totality of the spun yarn fit in a shoe box. It was remarkable.

Carding the wool was significantly easier than combing it and I managed to finish it all in roughly four days of work. The machine was much easier to use and functioned much more successfully when fed locks that has been pre-fluffed and, in many instances, halved or quartered. Although multiple sources assured me that carding raw locks is perfectly fine, my experience showed distinctly that it is best to comb everything first before attempting to card it. In any case, once I had my completed batts I was able to move on to dying.

4.5 Scouring the wool

Once the batts were successfully carded I was able to begin the chemistry portion of my research with scouring. It is important to note that correct scouring can make or break a fiber. For example, my scour recipe for mercerized cotton involves both detergent and washing soda, whereas my wool scour uses a gentle, yet thorough, soap. Specifically, I utilized Dr. Bronners’ pure castile soap. I did this for three primary reasons: firstly, because it was suggested in dozens of articles; second, because I already had plenty on hand and; thirdly, because I know it to be an extremely effective product. I have, as it happens, been using Dr. Bronner’s to hand wash clothing, clean my living space, wash my hair, and cleanse piercings and new tattoos for a little over fifteen years. I lament waxing into a tone of product placement, but the soap is just good for absolutely everything and it comes, highly concentrated, in enormous 1L jugs of various scents. It’s also certified vegan, organic, non-gmo, and is part of the Fair for Life Program. My preferred flavour is lavender, and that is what I used to scour the fleece.

The scouring method I used was fairly simple: one gram of Dr. Bronners for every one-hundred grams of wool, and enough water to submerge the fiber. In order to encourage even soap distribution between the fibers, I measured the soap into a jar then mixed it with approximately one cup of water. I then adequately submerged my individual batts in cold water, adding the diluted soap and stirred gently by hand. I then placed it over a burner set to medium and brought the whole bath up to temperature slowly. “Up to temperature” is relatively subjective, because it is not absolutely necessary to maintain exactly the same temperature down to the single degree. In practise, it is perfectly acceptable to maintain the bath without a thermometer; it should be steaming but not simmering or boiling. However, for the purpose of utilizing the scientific method to the best of my ability for my specific research here, I scoured my batts in 100g (+/- 5g) intervals and maintained each bath at 180F for thirty minutes before

draining and rinsing with scalding-hot tap water until it ran clear[2]. It is of great importance to adhere to the one universal rule of handling organic material: keep hot things hot, and cold things cold until you are ready to do something with them. This is especially true for wool, as a sudden temperature change can cause the fiber to felt irreparably. Therefore, there are three general rules to follow with regards to wool temperature when scouring, mordanting, and dying:

1. If the wool going into the water/bath is dry, the liquid must be cold or lukewarm. It should also be very well-saturated before going on to the heat.
2. When rinsing hot wool, use hot water. NEVER rinse hot wool with cold water or visa versa– that is a one-way ticket to Felt Town. The rinse water should be roughly the same temperature as the wool, so that leaves the dyer with two options: either allow the wool to cool before rinsing in cool water, or rinse the hot wool in the hottest water possible and risk burning one's fingers. Officially, for safety purposes, I must urge the reader to let the wool cool first. However, for academic honesty and research transparency, I did choose the latter method and I did burn each and every one of my fingers at different points throughout the process. I have no regrets.
3. When finished processing a batt, allow it to cool down to room temperature before the final rinse in lukewarm water. Gently unrolling the batt will ease with heat dispersal without the risk of felting it.

I repeated the same scouring method with all of my batts before mordanting and dying them in their respective groups. Although it is possible to scour, mordant, dry, and store batts for later use I decided to fully process one batt group at a time in case I wanted to make any changes to the scours or the mordants. Ultimately I made no changes to the scour, but I did play around somewhat with mordants.

4.6 Mordanting

As mentioned previously, I utilized Claire Boley's *Hand Spinning and Natural Dying* as my primary reference during this process. The mordant ratio I pulled from her work is 1lb wool: 1/4lb alum: 1oz cream of tartar. In order to accommodate my small batch sizes, I translated the recipe into grams (100g wool: 12.5g alum: 3.1g cream of tartar) and therefore will describe measurements in grams going forth. In the interest of maintaining scientific credibility, I must note that not each batt was 100g exactly – I recorded the weights of each batt individually and, therefore, one could replicate my process if so inclined. I also rounded the weights to the nearest whole digit, channeling the idea of "good enough". Therefore, the general ratio I officially used becomes this: 100g (+-5g) wool: 13g alum: 3g cream of tartar. I used this ratio to

[2] Another handy property of Dr. Bronner's soap: even the smallest amount will turn water notably opalescent. This property makes it easy to determine when all the soap has indeed been washed away.

mordant everything, but exact weights used for each dye batch can be found in their respective sections below.

4.7 The great dying (no, not the Permian-Triassic extinction event).

Dying is a blast. It's like a new chemistry set on Christmas but the box is unwrapped after enjoying the set. As mentioned above, I dyed the wool in batches. I have included the specific measurements of all components except the scouring; which the reader may infer I did at the beginning of each dye bath prior to beginning the mordanting process at a ratio of 1g Dr. Bronners: 100g(+-5g) wool.

As for the dye baths, I did my pre-thesis trial runs and I thought I knew what to expect; I did not. However, I made it work anyways and wound up, ultimately, extremely happy with the results. So, without further ado, it's time to dye (in chronological order).

4.8 Hibiscus and Iron (WGy10223)

I had such high hopes for this dye. I love hibiscus tea and it has stained many a tea towel of mine. So, I believed that, surely, I would be able to easily dye wool with it. I was, in a way, able to do so, and I did end up quite happy with the results, but that does not mean the results were what I expected. This dye lot was begun with three batts, totalling 97g and pre-mordanted as stated above. After it was mordanted, I let it sit (covered so as to remain wet) overnight. The next day I prepared a dye bath of 75g loose hibiscus flowers, 24g alum, and 6g cream of tartar steeped in 4200ml of water and processed for one hour. I also added the cold, wet wool to a pot filled with only cold water, bringing both the wool and the dye bath up to temperature simultaneously[3]. When I added the hibiscus to the pot it immediately stained the water opaque, and I had a good feeling about it. I had hoped that the loose flower heads would give the batt a mottled effect so that I could card it out and have one batt with many individual fibers of varying shades of pink, but that is not what happened. To my surprise the wool came out the soft grey of a dove or a kitten, but also had very even pigment distribution; the loose flower heads made no difference. Though it was not felted per se, there was some minor compaction of the fiber matrix so I opted to card it again. After doing some searching, I found a website that used hibiscus and an iron mordant to produce grey dye[4]. Eureka! I thought, the pot I used must be iron and therefore I added iron to my dye bath without realizing it. I decided to use a stainless steel pot for my next dye iteration with the addition of marigold, which I had success with in my earlier experiments. I was hoping for orange, or peach, but what I ended up with was a colour I can only describe as *tissue-like*.

[3] I warmed the wool in 4200ml of water as well in the belief that they would heat more similarly if the volume of water was the same. I have no scientific backing for this, it just seemed like common sense.
[4] https://www.mixedcolor.net/blog/2018/5/13/color-with-rust-making-an-iron-mordant

4.9 Hibiscus and Marigold (WTn10223)

I can say that it was, at least, reasonably well thought-out. I knew already that iron would dull out colours, and I reasoned that my tap water could also be alkaline. I hypothesized this because red cabbage liquid turns blue or pink when combined with a base or acid respectively. However, a quick test of my water with my aquarium kit revealed it to have a ph of 6.75; the softer side of neutral. I was, therefore, able to quickly rule out the tap water as a potential influence on the bath and decided to change to a steel pot. I hoped this would produce something similar to rose gold. I mordanted 145g of wool with 36g of alum, 9g cream of tartar, and 4200ml of water. The dye bath was 35g hibiscus (the same dyestuff to wool ratio as above), 14g dried marigold petals, 2g of citric acid, and 2100ml of water. Obviously, more dyestuffs and less liquid concentrated the dyebath, but only slightly. In the pot the dye was opaque and looked as though the wool would come out a medium red. However, when finished, the result was distinctly unsettling. I suppose the colour could be described as peach or rose-gold adjacent, but the exact colour much more distinctly resembled ground chicken or, more closely, my own skin. When held up to the light, the buckskin batt glowed red. Though I will concede to having a well documented affinity for the macabre, I can not say I was terribly pleased to come out with one hundred and forty five whole grams of wool coloured almost-rawhide-but-jucier.

I thought, perhaps, that the issue was the porosity of the wool. I have dyed mercerized cotton with marigold successfully and so I knew that was not the problem. I repeated the dye bath with mercerized cotton (appropriately scoured) and sans marigold. The result was the softest possible blush. This gave me three important pieces of information:

1. Hibiscus is not great dyestuff and is easily overpowered by other ingredients.
2. Considering colour theory in hindsight, mostly marigold-yellow mixed with a blush pink could only produce a buckskin tone.
3. If hibiscus is not great dyestuff for wool or cotton, I am misinformed about the specific fiber contents of my tea towels.

I decided to move on to something I believed stronger, while still trying to utilize dyestuffs that would be easily available to me (and anyone else attempting to replicate my work). For reasons which continue to elude me still, I was fixated on the prospect of producing a dye on the red-pink spectrum. Two winters ago, I made an attempt at borsht, permanently staining my favourite wooden spoon and I reasoned I would be able to do the same with wool. Therefore, I chose beets as the dyestuff for my next iteration.

4.10 Beets (WO10323)

I can’t say that I regret attempting to dye with beets per se, but I can say that I do not intend to ever dye with them again. I believe I was emboldened by my stained wooden spoon, and a dozen or so online articles which suggested beets but, in hindsight, they were not mentioned in

Claire Boley's work. Conversely, Boley expatiates the virtues of dying with rose petals, daffodils, and blackberries; which were all but unheard of in most other sources. I scoured and mordanted the two respective batts as normal. I then prepared two identical dyebaths in my steel and iron pots respectively. I reasoned that the steel would likely come out pink and the iron would come out some shade of grey or (hopefully) mauve. Both dye baths contained 715g shredded beet root, 350ml of red wine (for the tannins) and 2100ml of water. Much to my dismay, the dye bath did not adhere to the cheese cloth I used to strain it, so I added 10g of black tea steeped for ten minutes in 500ml of water to each dye bath (for more tannins). The end result was two identical orange batts. The material of the simmer pots had no effect whatsoever on the outcome. Somehow, it seems, only the tannins of the tea actually penetrated the fiber. Confused, I asked around to other borsht-makers and learned that a spoon being permanently dyed from one batch is nearly unheard of and that my spoon must have been of a remarkable inferior quality. This, combined with the questionable fiber makeup of my tea towels has reaffirmed my desire to source things at a smaller, more sustainable level. Obviously I did not give up at this point, but it became apparent that I needed to regroup if I was going to dye with any real success. So, I turned back to my Foolproof Turmeric Dye Recipe from the experiments I did during my proposal process.

4.11 Turmeric (WY10323-WY30323)

If I am honest, I did not want to go back to the turmeric dye. It is both simple and predictable, and I wanted to do something more "fun". I was completely disillusioned with my capacity to intuitively choose dyestuff and the turmeric, I knew, would at least yield predictable results. In order to keep this round interesting for myself I resolved to play with dye saturation for a gradient of colour results. What this means is that I simply dyed one batt at a time, topping up the bath with only water each time. I scoured and mordanted a total of three batts (weighing 11g, 7g, and 12g respectively). I then prepared a dyebath composed solely of 2100ml of water and 20g of fresh, grated turmeric. After each batt was processed and removed from the bath, I topped the total water level back up to 2100ml before the next batt was added. This resulted in the concentration of pigment being significantly lesser in each round. The results were the first I was truly happy with; the first batt (11g) was a deep dandelion colour, followed by a batt the medium pastel of a yellow rose (7g), and finally with a batt the exact colour of hand-churned butter (12g). I was beyond pleased and vowed to use this methodology consistently in the future, if for no other reason than because I find the gradient colours so intensely satisfying when lined up in a row. This success emboldened me to try something different. One dye plant I saw pop up again and again, particularly in Australian dye references, was eucalyptus.

4.12 Eucalyptus (WO20423-WO30423)

Though I personally resonate more closely with raccoons than with koalas, I have a deep love and respect for eucalyptus. It is extremely powerful medicinally and has been an integral

component of my holistic medicine bag for over fifteen years[5]. It also smells absolutely wonderful, and I'll freely admit I was more than a little excited to bescent my entire house with the fragrance. That same odor is the reason it is surprisingly easy to find bundles of fresh eucalyptus in Canada; virtually every flower shop carries it. I did once purchase a Rainbow Eucalyptus sapling but, shockingly, it did not do well sat in a pot in a Montreal living room and I lost it to, what I believe, was melancholy. The eucalyptus I used for the dye experiment is the variety most commonly available at flower shops: *Eucalyptus pulverulenta* or Baby Blue Eucalyptus[6]. Each of the dozen or so eucalyptus dye recipes I perused stated very clearly that an iron mordant will darken the colour to a near black. At this stage, I had given up on reds and pinks in favor of simply trying to create a semblance of a unified palate for the totality of my wool. The blue eucalyptus and the iron, I reasoned, would give me something neutral in the realm of grey or black; something to pair with the batt of *Hibiscus Grey*.

I began by mordanting two batts weighing 31g and 45g respectively; the former I did normally but, to the latter, I added 75ml of War Water[7]. The result was drastic: initially the War Water bath was opaque, but as it processed the wool apparently soaked up every single rust particle. The wool came out of the bath notably rust-coloured, and the liquid itself had become clear. It was almost like watching the curds separate from the whey in cheese making.

I then shredded the bundle of Blue Eucalyptus, which came out to a total of 113g plant fiber. The shredding and the simmering of the eucalyptus can only be described as delightful. I spent a significant amount of time hovering over the steaming-but-not-boiling dye bath, inhaling deeply and unclogging my pores. It was like a tiny spa treatment in my kitchen and I highly recommend the experience. When the bath was complete, however, I was flabbergasted: the dye was not blue, not green, and not grey, it was carrot-orange.

"No matter," I thought, "that second batt is so clearly different with just the mordant that I'm sure to end up with two distinct shades at least.".

I did not end up with two distinct shades.

This was, by far, the most surprising result of all of my work. While I will say that the War Water Wool was a hair darker than its counterpart, the difference was so negligible that, were they paint swatches, I would consider it a colour match. I do not know why the Dye Gods were so

[5] In the interest of accuracy and safety, I feel it important to clarify that I do not believe all illness can be or should be cured holistically. Just as there are varying degrees of illness, so too are there varying degrees of necessary medical intervention. Essential oils work wonders for things like colds, mild flus, muscle pain, and stress management, but they are no replacement for life-saving treatments such as vaccines and medications like antibiotics or insulin. Under no circumstances should anyone urgently or emergently ill avoid seeking treatment from a medical doctor and/or hospital in favor of holistic treatments.

[6] To stress the popularity among florists *Eucalyptus pulverulenta* is also known as *Florist's Silver Dollar*.

[7] War Water is a common ingredient in witchcraft; it is typically used for baneful or protective works. It is made by placing iron nails in a jar of water and vinegar until rust begins to form, turning the liquid orange and opaque. I did not make it for mordant specifically, but rather had it on my shelf already for the latter-mentioned purpose.

determined for me to produce so much of my least favourite colour, but I know better than to criticize their judgement. I have also noted that, where many articles state the mordant is simply “iron” others specify that it is iron *sulfate* which acts as a darkening mordant. I have inferred that there is a greater importance to the aspects of the sulfate than I had previously believed. At this point I lost what little faith I had left in my capacity to select dyestuff without some form of supervision. So, I did the only reasonable thing: I sourced a small local business that sells natural dye kits.

4.13 Logwood (WPl10423-WPl30423)

Sweet Paprika Studio is located in the Atwater area of Montreal, walking distance from the canal. They source and sell a variety of kits, including a dye sampler kit (which I purchased). The *Love of Colour Kit* came with instructions, sufficient alum for processing, and included the pigments Cochineal, Madder, Osage, Logwood, and Gallnut. As I had already produced so much yellow and orange in failing to make darker colours, I immediately vetoed the Madder and Osage in favour of Logwood.

I followed the instructions in the kit and began the Logwood dye process by making an “extract” of the pigment. I did this by adding the 8g of Logwood chips from the kit to 500ml of cold water (which immediately had the unmistakable appearance of turning the water into wine). I then, as usual, brought the mixture up to steaming-not-boiling and maintained the temperature for ten minutes. When the time was up, I strained the chips and added another 500ml of water. I repeated this a total of six times. The first steeping yielded 410ml of extract and was a dark, opaque purple. The second steeping yielded 450ml and was nearly opaque, like red wine. The third, fourth, and fifth steepings yielded 475ml, 470ml, and 475ml respectively. The sixth and final steepening yielded 480ml of extract and was translucent; it was at this point I deemed that I had extracted all significant pigment from the Logwood chips. In total I used 3,000ml of water to 8g of logwood chips; the result was 2,280ml of dye extract. Logwood is relatively heavy-scented and I spent as much time leaning over it, breathing deeply, as I did with the Eucalyptus. Though I have no regrets about this, in future I will double check to ensure that my dyestuff is not poisonous before hovering my face over a steaming vat of it. I had no reaction to the logwood other than a deep homesickness for freediving, but it is always best practice to ensure proposed inhalants are non-toxic beforehand, regardless of how good they may smell. It made my entire kitchen reek of a tropical paradise and allowed me to put a name to a scent I have always been particularly fond of. In no hurry to be finished my odorous practice, I elected to jar all of the extract and allow it to cool to a uniform temperature over night.

The next day I selected one batt weighing 36g and two which happened to both weigh 39g each. The kit came with a bulk stash of alum that converted to 18g of the powder for each 100g of wool, and made no mention whatsoever of cream of tartar. I followed these ratios for

mordanting rather than my own out of fear that I would somehow produce even more rust-orange, and used 20g of alum for the total 114g of wool.

To my immeasurable delight, on top of bescenting my kitchen once again, the first batt came out a dark, royal purple. The second came out as a mid-level lilac, and the third as a light lilac. In one afternoon, Logwood became my favourite pigment. I will be using it again in the future, but in larger quantities. I am still so enamoured with the results that I am considering dying my inevitable second fleece with logwood alone. I decided at this point that it was unlikely I would be able to get another pigment I personally loved quite so much as the Logwood, so I decided to harken back to my bachelor's degree (as well as my pre-thesis experiments) and work with my previous favourite: Cochineal.

4.14 Cochineal (WPi10423-WPi20423)

I am fascinated by Cochineal; it is one of the rare natural pigments derived from an animal source. The insects, of the same name, cling on to cactuses and suck out the plant's juices. When dried, crushed, and hydrated, they make a beautiful pigment. Had I just swallowed my pride and "cheated" earlier on my first dye baths by simply starting with the Cochineal and Logwood, rather than obsessing over grocery store dyestuff, I believe I would have ended up significantly happier with the results. Let this be a lesson; theoretically correct ideas are nice, but they do not replace having the practical knowledge and ingredients.

I did, however, vary from the instructions in the kit for the mordanting here because I have dyed successfully with Cochineal in the past, and know that my method will work. The first batt weighed 45g and was mordanted in 2800ml of water with 17g alum and 3g cream of tartar. The second (and final) batt weighed 44g and was thereby mordanted with 2800ml water, 16g alum, and 3g cream of tartar. I then referred back to the kit, simmering all 6g of cochineal in 700ml of water before straining the bugs out and adding another 700ml of water[8]. I repeated the steepening a total of four times, then processed it in a vat with my wool. The first batt, as expected, came out an intense red that bordered on magenta. The second was mid pink. I had (finally) produced what I was aiming for in the first place. Somehow it seems fitting that my first goal was completed dead last.

4.15 Dyed Carding

Carding the dyed wool was what I had been looking forward to most during this process. It's low impact, very easy, and produces beautiful results. It is possible that I am simply biased, but I have never looked at any rolag[9], in any scenario, and thought "well that doesn't look very nice".

[8] After the first steeping I crushed the hydrated beetles to release more pigment particles.

[9] A rolag is similar to a batt, but it is ready to be spun as-is. Typically, they have been dyed and contain a smaller volume of fiber than a batt would.

I want to describe the dyed carding process as similar to painting an abstract watercolour, but watercolour painting is a markedly more-stressful activity.

The process was also significantly less complicated than carding the combed fleece. Because the batts had already been carded, the tension within the batts was already adequate and I was able to lay the fibers directly onto the large wheel, bypassing the small one. This was easier, faster, and more pleasant because I was better able to see what I was doing. The act of laying down colours proved to be meditative, and produced results that I was very happy with across the board. After the monotony of carding and combing, followed by all of the math involved in the dying, the final carding proved to be several extremely enjoyable days. When I was finished with my rolags and found myself ready to get spinning, it was with a much renewed zest for the project over all.

Figure 24. All 41 rolags of wool, ready to be spun.

4.16 Spinning (the final fleecening)

Learning to use a drop spindle was almost as frustrating as the amount of orange dye I accidentally produced, but only for the first three or four rolags. Once I got the bare minimum of a "feel" for it, the activity proved to be meditative, constructive, and beautiful. Once I figured it out, I thoroughly enjoyed myself. The first few balls I crafted were of a significantly lower quality to the ones I ended with. By the time I had passed the halfway point in my rolag stock, I had developed a much more intuitive sense for the wool. The process is simple; one hooks some wool fiber from the rolag[10] and starts to spin the spindle[11]. Once sufficient torque has been achieved, more wool is pulled from the rolag and spun. Before I started spinning I was *theoretically* aware of double cuts and lower-quality wool but, regardless, I started with zero *tactile* knowledge of what those terms mean. I am now confident in my ability to spin, and am able to do so with reasonable speed.

The spinning process was extensive; each rolag took me an average of one-and-a-half hours to complete; which is an approximate total of sixty-one hours on spinning alone. During this time, I was able to meditate on the history of it, and I spent a significant amount of time thinking about how many other women before me had learned to spin. I wondered if they picked it up faster than I did. After all, my interest in string came from and was supported by my grandmothers; my Oma made sure I could sew before I started kindergarten[12], and my Nana gifted me the set of crochet hooks that turned my interest to yarn and, eventually, this thesis.

During the spinning process I also thought about how many women before me had stood over great bubbling cauldrons, inhaling the scent of herbaceous dyestuff, steaming out their pores; attended, just like me, by faithful cats who came for the warmth, the yarn, and the lanolin. It left me feeling more than a little like a string (no pun intended) connected me to all of them, and I found myself pondering on the generations yet to come, hopeful that in their time they will be able to look back at us and feel that same connection.

In my future endeavors, I intend to spin yarns that are much more complex than the single-strand balls I produced this time. Though none of it is particularly fancy, the important thing to note here is that it is of reasonable quality and is usable; which means that I was successful in my endeavor to create something that is useful outside of its purpose as object d'art.

[10] Another method of starting is to use a "lead yarn" that has already been spun out to begin the new yarn. This is, understandably, useful when trying to clone yarn or duplicate a specific weight.

[11] One may spin the yarn clockwise or counter clockwise. My preference is clockwise for two reasons; firstly, in western modern witchcraft, the clockwise direction is commonly understood to be generative in nature. Secondly, back home in Muskoka the dance circle at powwow runs clockwise. While correlation does not equal causation, and neither reason is "scientific" per se, the spirit of sufficiency makes it perfectly valid to have spiritual reasons for small decisions. After all, the direction the yarn we spin need only be preferable to ourselves.

[12] This is not an exaggeration; she gifted me a complete sewing set and a stash of material (some of which I still have) for my fifth Christmas.

Figure 25. A selection of spun yarn.

Chapter 5: Conclusions

The experience of processing an entire fleece was a roller coaster in its learning curve, in the sense that the various risers and falls undergone were, on the whole, an absolute blast. My studio-based process asked the question: how can I bring both scientific precision and sustainability into my visual arts practice and how might this inform art education practices? I am confident that the evidence presented here demonstrates that is it possible, if not preferable, to do this. As educators it is part of our job to ensure the long-term best interest of our students. It is therefore imperative to adjust our teaching methods accordingly by engaging in more sustainable, accessible, cross-disciplinary practices to address this concern.

I would also like to address the notion of accessibility to this new cross-disciplinary material. I have created media that is transcribed, visual, auditory, and tactile. The contents of this paper and the associated audio-visual media are available to anyone with an internet connection[13]. Thanks to advancements in AI technology, accessibility accommodations such as described video, subtitles, and auto-generated language translation are readily available. In a situation where none of these options are viable, it is still possible for one to glean the necessary information from simply watching the screen thanks to my footage of hard, numerical data cleverly disguised as b-roll. By engaging in more cross-disciplinary practice such as this, we serve only to broaden our own horizons and improve the quality of life on our planet in some very tangible ways.

If one were to implement this project in a real-life scholastic setting, it could be relatively easily organized if done as a grade-level project and modified to better suit the age of the students and the location of the institution. For example, a class of suburban second-graders could prepare by discussing the life cycle of wool, of sheep, and the other animals that can be used for fiber. They could invite an existing animal educator into the school so that the students could experience the creatures in real life. It is merciful circumstance that traveling “petting zoos” are relatively popular and almost always include textile animals such as sheep, rabbits, goats, and llamas or alpacas[14]. They could then take turns with hand carders to create their own batts. I would suggest hand carders in this scenario, as I believe drum carders are a great potential danger to small fingers. For a group this age, I would also avoid hot dye and hand spinning altogether. Instead, I would recommend wet felting, followed by either ice dying[15] or

[13] This may not be true in nations with heavy media censoring such as North Korea, Eritrea, or China. However, the same can be said with regards to all media, and some degree of inaccessibility is unavoidable at an international level without acts of literal espionage. While I believe that becoming a super-spy with the goal of uniting the totality of the globe through sustainable pedagogy would make a wonderful movie, it is not the aim of this thesis, nor is it remotely realistic.

[14] If available, the local chapter of the 4H Club would likely be able to assist with sourcing a demo sheep.

[15] Ice dying is a process in which an individual layer’s ice and powdered dye onto a fiber. As the ice melts, the water pulls the pigment down through the fabric. The effect is similar to tie dye.

floral dying[16]. Incidentally, as many elementary schools have "water days" during the summer weather at the end of the school year, there may already be an appropriate day or two in the academic calendar for activities such as fleece washing, ice dying, and wet felting. If orchestrated in this way, it allows each child to experience the whole process of textile production, and each child gets their own individual piece of the project. This is advisable in this age group for several reasons; firstly, it does not involve the potential insurance nightmare that would be taking a group of small children to an industrial wool farm or fiber mill, nor does it involve the equally nightmarish scenario of a near-boiling vat around those same children for the hours it would take to process a batt for each child in the grade. Lastly, children of this age are slightly more sophisticated in their ability to complete arts/science projects, but are not yet renowned for their skill in sharing when it comes time to decide who gets to take the group project home. Allowing each child to process their own small dye project outright simply mitigates a potential cause of conflict before it begins. While I will concede that a small, wet-felted, floral print does not hold secondary value outside of object d'art per se, but I would argue that most children this age would find some way to integrate their own project into their own toy box. Failing this, I'm sure that a majority of families have at least one adult that would dearly treasure such a one-of-a-kind project as a keepsake (or, even better, go on to use the piece in a larger textile project that DOES have objective secondary value such as a patch, sweater decal, or quilt square).

For older elementary and middle school children (say, seventh grade) the project could begin by discussing the effect that the textile industry has on the environment. it would be more appropriate for a more rural class to spend a day trip at a farm and/ or fiber mill to illustrate the natural textile process. Conversely, inner-city educators could send their students on a trip to the local mall with instructions to take note on which materials their favourite stores and brands use the most. They could then take turns using a drum carder to card their individual batts. Students could then dye their batts in groups based on which specific colour they wanted to dye their yarn (for example; turmeric, cochineal, or logwood groups) and decide together what they should use in their specific recipe. Though they would still require close supervision, it is relatively safe for children of this age to have a hot pot in the room. My recommendation for teachers would be to designate one colour to a day during "dye week" and draw lots to determine the order of progression.

Once the dying process finished, I would suggest an optional "fiber swap" where the students have the opportunity to collect samples of each-other's fiber, which they could then card into a rolag for spinning or use as base colours for a small hand felting project. Spinning would likely be more difficult than hand felting for children of this age, but it is most certainly possible, and I

[16] Technically very similar to wet felting; one places flowers and plants onto a piece of textile, wraps it tightly, then rolls and compresses it. This damages the plant tissue, releasing pigment which is then absorbed by the fiber. This technique typically leaves very obvious impressions of the plant used to make it.

would encourage at least a spinning demo for the visual and tactile lesson of how much is actually required for a simple piece of string.

The high school level is where the implications of this project start to become truly apparent. First, I must provide some context: I went to an exceptionally good public high school. We hosted the regional arts program and had champion athletic teams across the board; but we were also located in the middle of a cattle field. Therefore, we had a cross-disciplinary student body with a penchant for cabin fever[17]. The school's solution for this was cross-disciplinary field trips where various classes from various subjects would go on the same field trip with different focus objectives. For example, if one were to do this with my program at a fiber mill, a photography class would take pictures, a visual arts class would make sketches, an architecture class would analyze the design of the building, an auto or engineering class would examine the mill machinery, a business and/or accounting class would do a talk about the realities of managing a mill via the numbers. The same concept is possible for in-class settings; for example, a chemistry class could experiment with dye recipes, or a health class could examine fetal sheep development. Waxing into the slightly more macabre, the Ontario grade twelve biology curriculum includes a dissection of a fetal pig and, though it is not a particularly appetizing suggestion for me personally[18], biology students could instead dissect lambs. In theory, there is no limitation on which classes could be included in the project.

In terms of physically processing the wool, teenagers in the twelfth grade are more than capable of using drum carders and hot dye methods. Due to their near-adult age and the relative time frame of fleece processing, I would also give them both in-class and at-home time to complete the work. The program could be sufficiently completed with one day of in-class dye work, but I feel that a project of this magnitude deserves the opportunity for students to go farther on their own time if they wish.

Similarly to the middle school curriculum, I would encourage these students to engage in a fiber swap before embarking on their final carding and textile processing. In contrast to elementary or middle schoolers, young adults are perfectly capable of learning to spin as well as knit, crochet, or nålbind. The specifics of this cross-disciplinary handicraft are subject only to the whims of teacher and student, and that is part of what makes my theory so successful.

You may be wondering why I consider this project a success when four of the seven dye baths did not turn out the way I had hypothesized they would. However, even though not all of the dye baths turned out as I expected, the dyes that produce flawless results each time merit not more experimentation or thought; once the formula is finished, that is the end. So, in a way, the

[17] I was the second generation to attend Mayfield Secondary School and it continues to live on in local infamy. Over the years the "cabin fever" manifested in ways including (but not limited to) goldfish in the bathroom sinks, crickets in the cafeteria, a cow statue placed on the roof (stolen from my neighbor, Bill), a real cow on the third floor, the release of a trio of pigs labelled "1", "2," and "4", and a mock zombie takeover that I may or may not have participated in.

[18] Despite being reasonably squicked out, I did, in fact, dissect the pig.

work is more meaningful when it does not turn out as anticipated, because that paves the way for more questions, more research, and (hopefully) more answers.

The search for knowledge, much like the drive to create, is limitless and universal; just like our capacity for empathy. This empathy can only be compounded upon by a better understanding of each other. In order to make sure that we continue to do this in a fast-paced, science-based future, we all need to adopt a cross-disciplinary approach to learning. In the field of evolutionary biology, it is understood that animals which are too highly specialized are often at greater risk of extinction. It is the adaptable, all-purpose type animals that stand the test of time from an evolutionary perspective; think small mammal, think raccoon. Another cross-disciplinary (and raccoon-ish) trait I whole-heartedly endorse is the capacity to manage with what is available to oneself. Although it may not seem like it with the use of logwood and cochineal, I did obtain all the materials I used for this thesis within walking distance of my home. Granted, I will admit I won the dye supply lottery in terms of location, as during my process I lived within walking distance of both Atwater Market and Sweet Paprika. While not everyone will have access to logwood chips or cochineal beetles, if we adopt a principle of using what is available to us we are sure to find something. In addition, with the rise of globalization, the variety of ingredients that are available is ever expanding. For example, turmeric is now widely available at virtually every metropolitan grocery store in Cannada; whereas 20 or even 10 years ago this was very much not the case. Furthermore, if someone is unable to find the materials in their own home or in their local community, most of us will have the option to order things online. It is also important to keep in mind that “what is available to us” doesn’t apply to only materials, it also applies to knowledge. If we have access to communal and ancestral stores of knowledge and choose to not use them, we very much risk losing them. A sobering, but related, example of this in medicine is that humanity very nearly lost penicillin. This is largely due to the fact that putting mold on a wound does, in fact, sound like an insane folk remedy. But the reality is that insane, old, folk magic remedy works, and it has saved millions of lives. Penicillin is an antibiotic, regardless of whether it is being administered by an ancient village wise woman or a modern city doctor. The only distinction between the two is a social construct based off a shared acceptance of the standard required for testing and knowledge gaining; that being, of course, the scientific method.

Unfortunately, a side-effect of this standardization has been an increase in the belief that some ways of knowing are inherently superior to others; and the false belief that one way of knowing is somehow better than the other only serves to create hierarchies. Those hierarchies then lead to further division and, ultimately, sew discord amongst groups that should be collaborating. This lack of cooperation serves only to further the specialization and mystification that we addressed earlier through Assimov. The best way to combat the damage that has already been done, as well as prevent more damage from occurring in the future, is to immediately adopt radical new ways of cross-disciplinary thinking and teaching, such as the one I have outlined here. If we do this, we will quickly dismantle the illusion of science as wizardry. After all, in the

same way that penicillin is only a mold until it is a powerful antibiotic, magic is only magic until it’s science.

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