

# explorations

THE TEXAS A&M UNDERGRADUATE JOURNAL

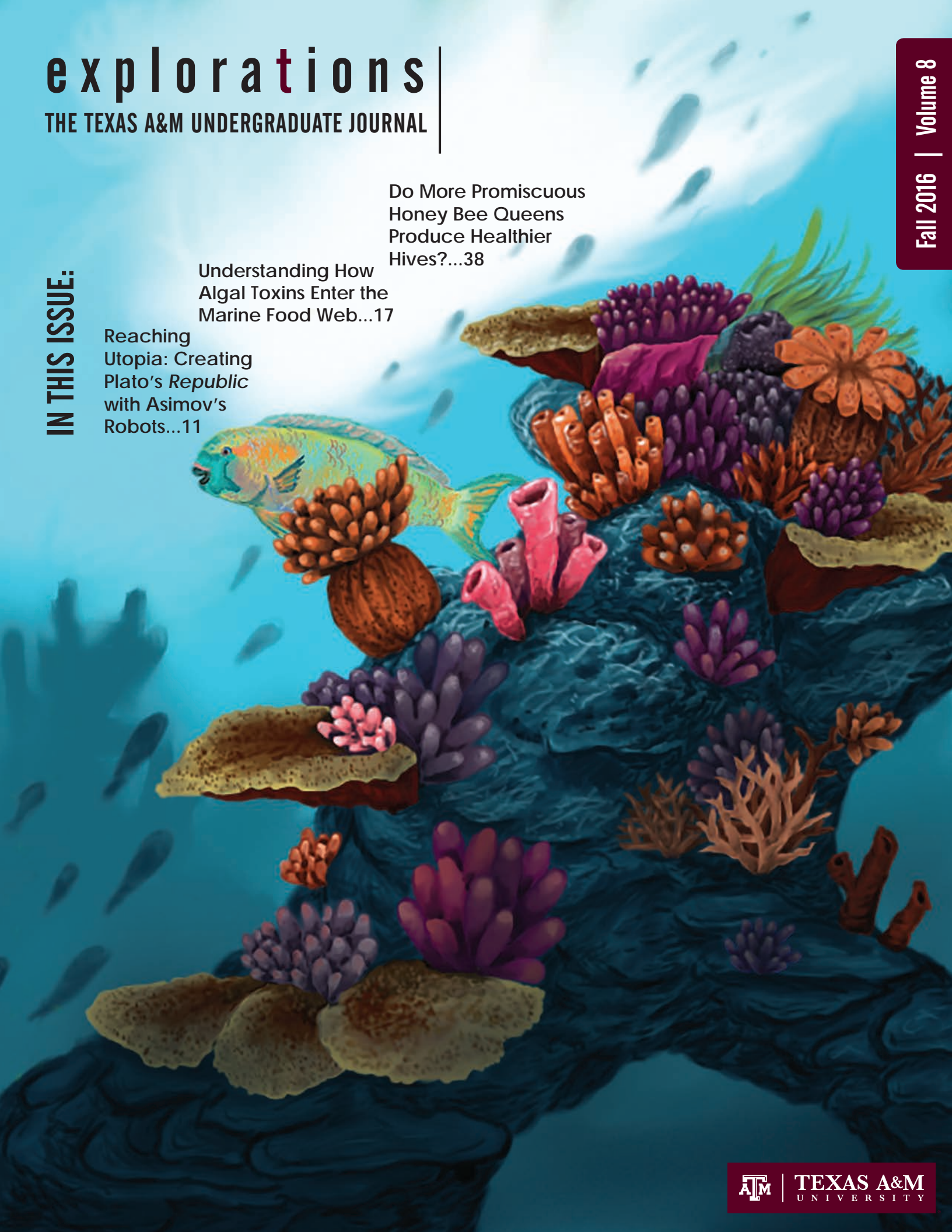
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Cover art by Karla Chang-Gonzalez based on the article  
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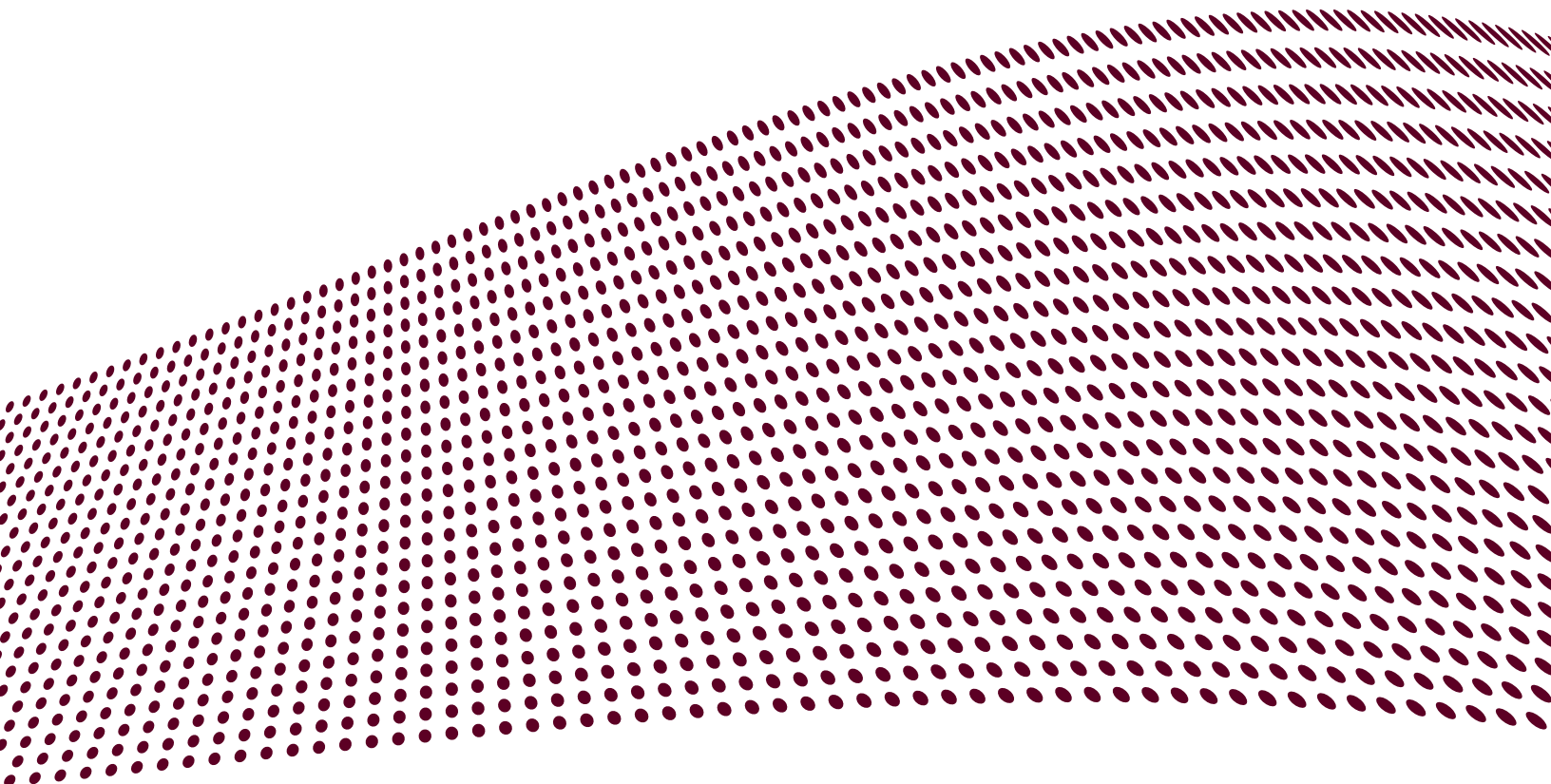
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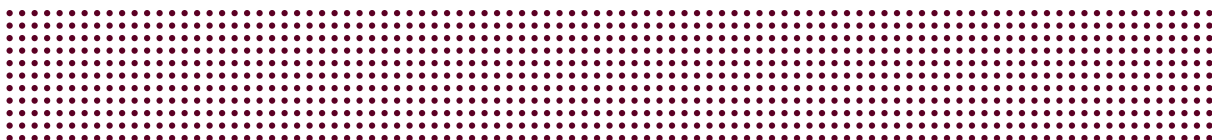


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# A LETTER FROM OUR FACULTY



I was delighted to be asked to share opening comments to the 8<sup>th</sup> issue of *Explorations* in my new capacity as Associate Director of Undergraduate Research in LAUNCH. It is exciting to work with students and faculty that are committed to producing the highest levels of scholarly and creative work in research and publishing at Texas A&M University. For me the student-led journal demonstrates what Aggies do best; they lead by example. I hope you will take a moment to be inspired by your fellow classmates and students, and I hope that will, perhaps, spark something in you as you follow your own passion for learning and exploring the world.

We know that writing across disciplines has positive effects on cognitive development and impacts learning in meaningful ways. As a faculty

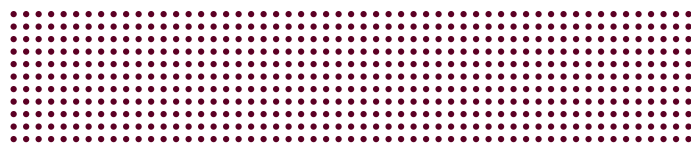
member in Hispanic Studies, language is central to what I do every day in the classroom. The American Council on the Teaching of Foreign Language (ACTFL) reminds us in its Statement of Philosophy that: “Language and communication are at the heart of the human experience” (actfl.org). Being able to express oneself through the medium of writing or to communicate effectively through the expression of other creative scholarly work prepares students with the knowledge and ability to be competent contributors and stakeholders in both their local and global communities. Inquiry, analysis, and self-reflection are skills that form the basis for good research. They are also the necessary building blocks for life-long learning because they provide strategies for problem solving and critical thinking. A life lived to the fullest will be measured by these rich human experiences and one’s ability to engage with them in profound ways.

In the following pages, I believe the reader will find that our students in *Explorations* are being deeply and utterly transformed through their passion for learning and by sharing their research. We thank those student contributors (writers and board members) for inspiring us to think and use our knowledge in creative ways. We also thank the faculty mentors for their work both inside and outside of the classroom. And, finally, we would like to thank the reader for taking a moment to pause, engage with the material, and appreciate these student leaders for their work on this fine issue because, as I hope I have conveyed, they are the heart of the human experience and the reason for everything that we do at Texas A&M University.

A handwritten signature in black ink, reading "Sarah M. Misemer". The signature is fluid and cursive.

**Dr. Sarah M. Misemer**  
Associate Director, Undergraduate Research  
LAUNCH  
Texas A&M University

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## **Tearing Down the Wall between**

# **ANIMAL SOUNDS & HUMAN MUSIC**

*By Dillon Jones*

### **Introduction**

Man-made music is estimated to have originated more than 500,000 years ago—with bone instruments emerging 40,000 years ago—ending with our modern plethora of music.<sup>1,2</sup> Initial uses of music may have been for communication or social bonding that possibly formed the basis for our language. Tonal languages, such as Mandarin or Cherokee, are languages where the use of a different tone while speaking is enough to change the meaning of a word. These languages still contain musical characteristics within their spoken form.<sup>2</sup> We can use musical characteristics to analyze and categorize any sort of noise. However, deciding at what point sounds become music is problematic. Our culture often describes bird communication as songs and whale communication as a duet, but some circles consider defining animal sounds as music to be controversial.

The problem here lies with the fact that *music* has no one universal meaning. Because of its subjective nature, music has a near-limitless number of definitions and interpretations. Opinions include everything from calling it an organized production of human-made sounds

to anything pleasing to the ear. If we agree that music is any noise that is pleasing, then naturally animal noises can be music. However, if we believe that music must be purposefully made by humans and contains characteristics such as tempo, rhythm, and harmony, then animals are never making music, even by accident. With this spectrum of beliefs, it is nearly impossible to accurately classify anything as music that isn't anthropogenic in origin.

***“Because of its subjective nature, music has a near-limitless number of definitions and interpretations.”***

Although the validity of animal-created music is disputed, the underlying musical qualities of animal sounds can be analyzed and classified. Humans have a tradition of categorizing animal sounds by using common musical terms; think of singing birds or harmonizing wolves. Also, an ever-expanding library of musical criteria exists with which to classify sounds. Juxtaposing animal sounds with musical attributes may be

beneficial for tracking and identifying wildlife and understanding the meaning of their communication. In my research, I attempted to determine the validity of musical characteristics as a means to classify animal sounds.

A prerequisite in many definitions of music is that the creation of music must be intentional and have a purpose, such as invoking an emotion. Both requirements are vague at best. After all, how is birdsong with the intent to attract a mate any different from a pop love song? These definitions are worded to imply that the artist must have, at the least, a basic understanding of music. Studies in the animal kingdom have found that animals recognize and act on basic musical characteristics. For example, bonobos, a closely related species to the chimpanzee, are naturally musically inclined. When researchers played a metronome at 280 beats per minute, the bonobos could synchronize to the beat on specially made “bonobo drums.”<sup>3</sup> Many parrots can bob their heads to the beat of a song, keeping in near-perfect time. Thailand has an orchestra composed entirely of elephants that play a variety of instruments. These examples indicate, at the least, a basic



recognition of fundamental musical qualities.

Animals use calls, complex or simple, for communication. Whales call back and forth to one another in long, drawn-out cries, varying their pitches to alter their meaning. Birdsongs and calls are typically composed of whistles and shrills at different pitches and different compositions. Wolves howl over long distance to communicate with one another, typically harmonizing with another wolf as they call out. All these communication styles exhibit individual characteristics of music by themselves. Often these calls are characterized as pleasing or musical. Countless CDs of nature sounds, animal calls, or pieces using musique concrete—the direct inclusion of animal sound recordings in compositions—are sold and marketed as music.

## Discussion

### *Birds sing love songs*

Birdsong is the animal sound most often associated with music. Birds vocalize with either calls or songs. Bird calls are simple and are used primarily to communicate basic instructions. They vary to mean anything from “danger is present” to “follow me” and are typically composed of short peeps, squawks, and chatter. Birdsongs, on the other hand, are more complex, composed of noises different from those of bird calls, and used almost exclusively to attract mates. Birdsongs are often melodious, much longer than bird calls, and are unique to each species. Some species have more pleasant songs than others, with some showing key musical characteristics. The Hermit Thrush for example, is a medium-sized songbird whose song exhibits harmonic series—a major component of nearly all music.<sup>4</sup>

Birdsong is most developed in the order Passeriformes, encompassing cardinals, wrens, crows, and what

## **Harmonic Hermit Thrush** **(With a Scale) Song Audio** <http://tx.ag/Jones1>

humans typically perceive as musical birds. The songs of the nightingale are often considered the most beautiful birdsong known to humans and exhibit an array of whistles, trills, and gurgles with the defining characteristic of a loud whistling crescendo. The nightingale has been the inspiration for and the subject of a variety of songs, poems, and other artistic works, such as “Oh, Sing Sweet Nightingale” and “Ode to a Nightingale.”

Birdsong is often sold in CD sets with the intent to relax and connect a person to the natural world. Birdsong used within music has taken on a variety of forms. Songs such as “Blackbird,” by the Beatles, or “Goodbye Blue Sky,” by Pink Floyd, use recordings of birdsong in their music as a form of musique concrete. However, birdsong can directly inspire songs and compositions, such as “The Lark Ascending,” by Ralph Vaughan Williams, and “Sumer Is Icumen In.” Many of these composers transcribe birdsong, to the best of their ability, directly into music. Oliver Messiaen is well known for using birdsong in his compositions and for his ability to transcribe birdsong.<sup>5</sup> One notable example is the transcription of the prairie chicken mating call into a composition.

## **Prairie Chicken** **Call Audio** <http://tx.ag/Jones2>

## **Orchestrated Prairie** **Chicken Call Audio** <http://tx.ag/Jones3>

### *Whales play jazz*

Whale song has long been studied for its musical ability. One maritime researcher (Payne) refers to whale


song as a type of jazz. Humpback whales sing by using call and response, a component typically found in jazz music between a singer and an instrument wherein one makes a sound and the other creates a complementary response. The whales continue the song with a repeating cycle of back-and-forth calls for the duration of the conversation. Payne studied humpback whales so exhaustively that he can sing some whale songs note for note. Also, not only is a song a collaborative effort, but the song evolves with each whale adding a unique element with every response. In one humpback duet Payne found that the song had begun with only six elements but evolved to eventually contain 14 elements 2 years later. According to Payne, what makes the whale songs actually music is that the songs exhibit a pattern. They are not just a random collection of sounds that occasionally create rhythm; they consistently and regularly exhibit rhythmic pattern and order.<sup>6</sup>

## **Whale Song Audio** <http://tx.ag/Jones4>

CDs, playlists, and hours of whale song recordings are marketed as music. Whale song is inherently harder to input into human music because it operates in a different medium. Whale song is meant to travel through water, a characteristic of its low-pitched nature, whereas human music is meant to travel through the air. However, some pieces draw direct inspiration from whale song, including “Vox Balaenae” (translated: “The Voice of the Whale”), by George Crumb. Paul Winter traveled aboard the *Greenpeace V* along with two other musicians in an attempt to use music to communicate with whales. He later made the album *Missa Gaia/Earth Mass* in 1982, one movement of which uses a four-note motive of whale song to open and close the song.

## *Wolves howl the blues*

*Missa Gaia/Earth Mass* also contains several recordings of wolf howls. Wolves are not typically marketed or used as biomusic, music created by nonhumans—perhaps because wolf calls are not as long or as continuous as bird or whale song. Wolf howls may be composed of only a single continuous howl or broken into individual howls. However, when a wolf is “singing,” changes in pitch occur along with a set rhythm and noticeable calls that sound in-tune with one another.<sup>7</sup> Certain parallels within the call that are typically found in music also exist, such as a quick rise in pitch, a long hold, and a fall in pitch. A solo wolf call, when transcribed into a piano piece, sounds eerily similar to a human-made musical piece.

 **Lone Wolf Howling**  
(MIDI) Audio File  
<http://tx.ag/Jones5>

Wolves are even found to harmonize with each others' howls, performing a form of wolf duets.

Wolves howl for a variety of reasons, such as to hold territory, scare off enemies, or confuse prey about the wolves' true location. However, most wolf calling occurs in winter months while wolves are trying to court one another. The social structure of wolves relies heavily on their howling and more likely than not can serve as a parallel to our own musical history and evolution. Although albums such as *Missa Gaia/Earth Mass* use wolf recordings within the music, few pieces exclusively display wolf calls in the same fashion as birdsong or whale call. However, wolves have held an important cultural and spiritual place in many societies around the world. Found more often in North American and Eurasian societies, wolves have been symbolized as everything from ferocious warriors

to demons. The long-held belief that wolves are fierce predators and the advent of lycanthropy, the myth of transformation of man into a wolf-state, in several cultures around the world has led to a plethora of music inspired directly by wolf howls.

The band Wolves has a song titled “Tribute to Wolves,” which uses wolf calls. These animals remain a heavy influence in traditional Celtic and Native American music; often entire albums are based on the elusive and mystical nature of wolves.<sup>8</sup>

## Conclusion

Music is a powerful and diverse field in which many elements, viewpoints, beliefs, and styles come together as one. Classifying sounds, whether animal- or human-made, as music or not music is simply impossible. The perception of what music is falls on a spectrum and varies extraordinarily from person to person. Although individual characteristics, such as tempo, rhythm, and pitch, can be identified and defined, ultimately what the end listener deems as music is, to that person, music. Nature may seem to be random, but taking time to identify the elements and underlying patterns can yield phenomenal discoveries. Although parallels to elements of human-defined music can be found within nature, the belief that whale calls, birdsong, and howling wolves are music is purely within the ear of the beholder.

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# *Using Electron-beam* **Food Processing Technology** *to Develop Foods for* **Long-duration Space Missions**

*By Sohini Bhatia*

## **Introduction**

Most people look forward to a variety of high-quality and appealing food. This is even more important if you are in a spaceship, submarine, or similar remote location that offers little in the way of entertainment or interaction. As part of NASA's mission to explore a variety of destinations such as near-Earth asteroids, the Moon, and eventually Mars, NASA must develop food that is healthy and suitable for astronauts.<sup>1</sup> Food and mealtimes are instrumental in reducing the stress and boredom of prolonged space missions, so the food's acceptability in terms of appearance, flavor, texture, and aroma has significant psychological ramifications for astronaut performance.<sup>2</sup> When astronauts first started eating in space during the Mercury missions in the early 1960s, the products consumed in flight were unappetizing bite-sized cubes, freeze-dried powders, and semi-liquids in aluminum tubes.<sup>3</sup> As the missions increased in length, more emphasis was placed on the packaging, taste, and nutritional aspects of the food. In recent years, a main focus of the space food program has been to extend the shelf life of the food.

Seven categories of food are consumed on the International Space Station (ISS) (Figure 1): Thermostabilized, irradiated, rehydratable, natural form, fresh food, extended-shelf-life bread products, and beverages.<sup>4</sup> Meals are combinations of these forms of food, where a meal may contain, for example, shrimp cocktail (rehydratable), beef steak (irradiated), corn (rehydratable), baked beans (rehydratable), macadamia nuts (natural form), chocolate pudding cake (thermostabilized—foods heated at specific high temperatures), and apple cider (beverage).<sup>5</sup>



**Figure 1.** “Assorted bags of snack food and dehydrated food, as served on the ISS” by NASA is in the Public Domain (PD-USGov-NASA). Source: [http://www.nasa.gov/audience/formedia/presskits/spacefood/gallery\\_jsc2003e63875.html](http://www.nasa.gov/audience/formedia/presskits/spacefood/gallery_jsc2003e63875.html).



Although-thermally stabilized foods have generally had the greatest potential to maintain their quality for 3–5 years, the temperatures required for stabilization can destroy nutrients and drastically change the appearance of food.<sup>6</sup> Because food-dedicated refrigeration is not available on the ISS or on any space vehicles, space-food processing must prevent microbial spoilage and chemical deterioration, and most importantly, eliminate microbial pathogens (disease-causing microorganisms) that can be hazardous to astronaut health. Thus, one of NASA's goals is to explore and develop nonthermal technologies that can ensure microbiological safety while maintaining the integrity of the food in terms of appearance, flavor, texture, and aroma.

## Background

Electron-beam (eBeam) processing is one such well-established nonthermal technology.<sup>7</sup> This technology is widely used in highly regulated medical device and pharmaceutical industries as well as in the commercial food industry.<sup>7</sup> In eBeam processing, electrons are pulsed from an electron gun, creating a continuous beam. The accelerated beam is then showered over and into the intended product thereby inactivating the microbes, if present. The amount of energy applied to the product is highly controlled, so the nutritional or sensory attributes of the food are unaffected.<sup>7,8</sup>

It is critically important that the eBeam dose is optimized.<sup>9</sup> As with any food processing technique, the higher the dose applied to the food (be that heat, irradiation, or pressure), the more damage it will sustain (Figure 2). Although astronauts have consumed irradiated foods since the Apollo 8 mission in 1968, the Food and Drug Administration (FDA) requires a minimum dose of 44 kilogray (kGy—a measure of absorbed radiation dose) to sterilize frozen, packaged meats used as space foods, a dose that we hypothesized was unnecessary. Our hypothesis was that the same level of sterility could be achieved at a much lower dose. After considering the effectiveness of doses between 8 and 15 kGy, we chose 15 kGy as the target lower dose that could achieve the same level of sterility as 44 kGy.

## Methods

To benchmark the minimum eBeam dose required to sterilize space food, a mixture of multiple pathogenic *Escherichia coli* strains and bacterial endospores from the bacterial spore-former *Clostridium sporogenes* were added at high concentrations to a portion of the test space food, beef fajitas, an item currently on the US space food

menu. This sample was triple sealed in plastic pouches before being placed within a larger retort pouch (commercial laminated packaging made of alternating layers of metal foils and flexible plastics) filled with beef fajitas (Figure 3). This was done so that the inoculated beef fajitas would receive a dose most similar to the dose that would be received within a regular package. *E. coli* was used because of its prevalence with beef, whereas *C. sporogenes* spores were chosen as a surrogate for *C. botulinum* spores, a pathogen of key concern in the food industry.

The retort pouches were exposed to the defined (0 and 15 kGy) doses at the eBeam facility at the National Center for Electron Beam Research on the Texas A&M University campus. After eBeam processing, the samples were brought back to the microbiology laboratory for microbial analysis using specific culture media, allowing for the identification of specific and targeted microorganisms. Non-irradiated and non-inoculated control samples also were included.

## Results

The commercially purchased (non-inoculated) beef fajitas naturally had 10,000 colony-forming-units per 25 grams of food. At a target dose of 15 kGy, no samples showed the presence of any viable organism. In samples inoculated with *E. coli*, a 10 log (99.99999999%) reduction was observed, whereas samples inoculated with *C. sporogenes* spores saw a reduction of approximately 7 logs (99.99999%) at this dose.



**Figure 2.** Beef fajitas processed with increasing eBeam doses. With each increased dose, color appears to fade and moisture is released from the food.

**Table 1. Bacterial Log Reduction at a Target Dose of 15 kGy**

Organism	Log Reduction
Background aerobic bacteria	≥ 5
<i>E. coli</i>	≥ 10
<i>C. sporogenes</i> spores	7





**Figure 3.** Retort pouches filled with beef fajitas.

Bacterial endospores are significantly harder to kill than vegetative bacteria due to the multiple outer layers that protect the cell. This explains why at the same dose of 15 kGy, *E. coli*—a bacterium that does not form endospores—was reduced in larger amounts than *C. sporogenes* spores. If thermostabilized products are to be considered the “gold standard” in terms of safety, then the objective of this experiment was to obtain a 12 log reduction (99.9999999999%) in the products inoculated with *C. sporogenes* spores. The 15 kGy target dose does not meet this standard, but still yields a 7 log (99.99999%) reduction in spores—a substantial decrease in harmful bacteria. A detailed analysis is needed to determine the necessity of a 12-log reduction dose that sacrifices taste and appearance, compared to a 7-log reduction dose that retains these attributes.

## Conclusion

Electron-beam processing is a proven commercial non-thermal technology that can be used to process foods without heat, allowing them to retain their original quality and at high enough doses, and be shelf-stable for extended periods. Not only can these products be used for space travel, but they also have military and disaster preparedness applications due to their extended shelf lives. Although the decreased dose of 15 kGy does not fully meet current NASA standards (12-log reduction of *Clostridium* spores), additional studies are needed to establish the dose that will achieve the 12-log reduction. The 7-log reduction of spores achieved with 15 kGy leads us to believe that there is still potential to reduce the minimum required dose for space foods from the current 44 kGy.

## Acknowledgments

I thank my advisor Dr. Suresh D. Pillai, as well as staff members at the TAMU Department of Nutrition and Food Science, the National Center for Electron Beam Research, the Texas A&M Space Food Facility, and all NASA food scientists who helped make this project a reality.

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# Spinal Cord Injuries and Pain: An Unfortunate Combination

*By Melissa Brumley*

## Introduction

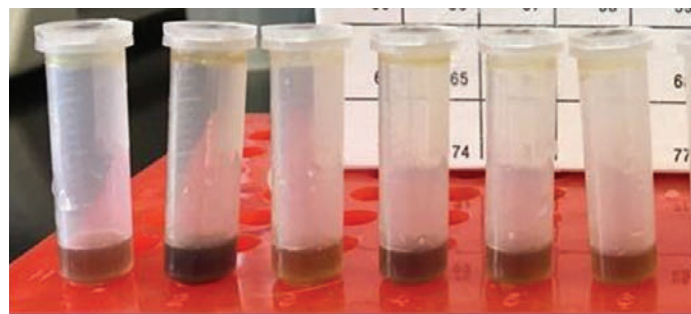
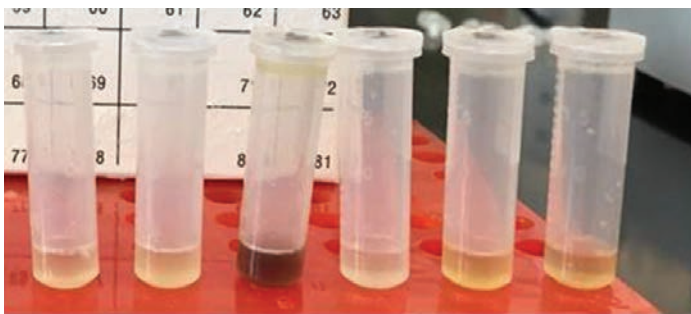
The spinal cord's basic function is to coordinate communication between the brain and the body, allowing us to perceive and navigate our environment. Spinal cord injury significantly impairs the transmission of sensory information from below the injury site to the brain. Injuries such as broken bones, lacerations, or burns often accompany the major causes of spinal cord injuries, which include vehicular accidents and violence. Because of the spinal cord injury, patients may not even be aware of these accompanying injuries since the pain from them does not reach the brain. However, even without the conscious perception of pain, the spinal cord continues to receive pain signals. The stimulation of neural circuits responsible for pain is called nociception. Research in our lab shows that the painful, or nociceptive, input from additional injuries significantly reduces recovery after a spinal cord injury. Subjects with additional injuries cannot move as well, experience more neuropathic pain, and are more likely to die than subjects without additional injuries. We see this negative impact on recovery only if the subjects receive pain input within 48 hours of the spinal injury.<sup>1</sup> This model is clinically relevant because most injuries occur at the same time as the spinal cord injury, leading us to ask: Why does pain input soon after injury impair long-term recovery?

## Background

In traumatic spinal cord injuries, the events that unfold immediately after injury occur in two stages, referred to as the primary and secondary injury phases. The initial trauma to the spinal cord, characterized by the physical destruction of cells and blood vessels, constitutes the primary injury phase. The combination of decreased blood flow from compromised blood vessels and physical trauma to cells results in extensive cell death at the injury site.

**"EVERY YEAR,  
MORE THAN  
12,000 NEW CASES OF  
SPINAL CORD INJURY  
OCCUR IN THE U.S.  
ALONE."**





**Figure 1.** Protein extracts from subjects with spinal cord injuries without (left) and with (right) painful stimulation. Extracts from subjects who received additional pain appear darker and more red.

The damaged tissue begins releasing chemical signals that attract immune cells to the injury site. As a result, the spinal cord becomes inflamed and hypersensitive—prime conditions for the secondary injury phase. In the 48 hours after the injury, the primary lesion expands rapidly as a cascade of cell death radiates outward from the lesion. This phenomenon characterizes the secondary stage of injury.<sup>2</sup> The vulnerability of the spinal cord to painful stimulation appears to be connected to the events in this stage, particularly the inflammation.

Inflammation is a reflexive response by the immune system to attract circulating immune cells to sites of injury. In most instances of tissue damage, this response has a positive healing effect. However, after spinal cord injuries, processes designed to aid healing in other tissues can have an adverse effect. The immune cells help the body respond quickly to potential infections as well as facilitate the cleaning up of dead and damaged cells to promote healing. However, the chemical signals released during inflammation also damage the surrounding tissue and can result in additional cell death.<sup>3</sup> Why is inflammation a potential problem after spinal cord injuries? Unlike most other types of cells, neurons have little capacity to regenerate, which is why people do not recover completely from spinal cord injuries. In addition, neurons are particularly sensitive to

inflammatory chemical signals. The combination of these two factors explains the devastating effects of the secondary phase of injury, which can double the amount of tissue lost. We hypothesized that nociceptive input may be exacerbating the inflammation at the lesion site, which would increase the amount of cell death and contribute to other adverse effects (e.g., chronic pain and/or spasticity).

## **"PATIENTS MAY NOT EVEN BE AWARE OF THESE... INJURIES SINCE THE PAIN... DOES NOT REACH THE BRAIN."**

To test this hypothesis, we measured the amount of inflammatory chemical signals at the lesion site in subjects who received either a spinal cord injury and stimulation of pain fibers or just a spinal cord injury. While running the experiment, Joel Turtle, an MD–PhD student, made an unexpected observation: the protein extracts from subjects who received painful stimulation were darker and more red than their counterparts, suggesting the presence of blood (Figure 1).

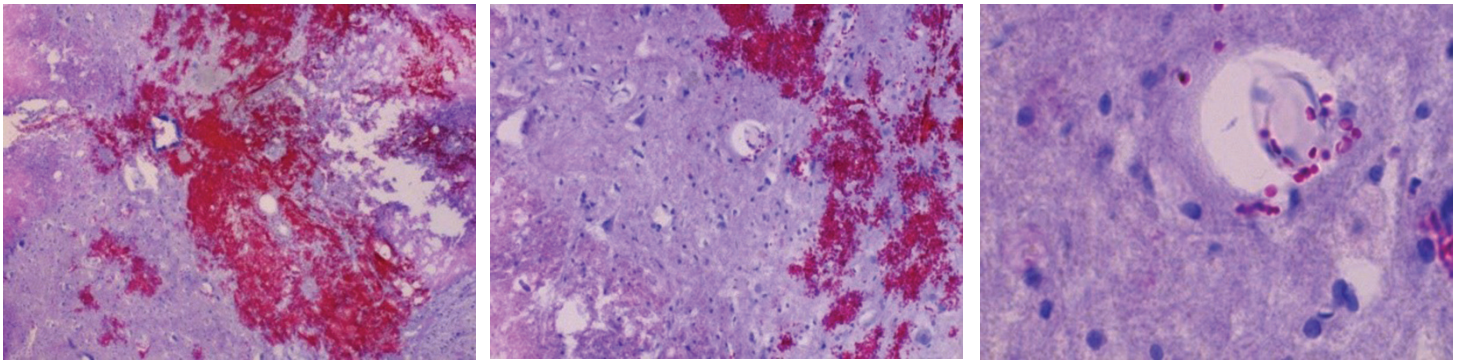
The brain and spinal cord—which make up the central nervous system—are enveloped in a special filtering mechanism called the blood–brain barrier and blood–spinal cord barrier, respectively. This filter tightly controls what enters the central nervous system from the blood, protecting the sensitive neural cells. Normally, this semipermeable filter does not

allow red blood cells to pass into the brain and spinal cord. So the fact that the protein extracts appeared bloody suggested that the blood–spinal cord barrier was severely damaged. The functioning of this important barrier is impaired after injury, resulting in a localized and temporary increase in permeability, perhaps to allow the passage of immune cells into the damaged nervous system.<sup>4</sup> However, red blood cells typically cannot bypass

a structurally intact blood–spinal cord barrier, extrapermeable or not. The dark, red protein extracts could mean that we are

observing more than just a temporary disruption in the barrier's function; the additional pain could be facilitating the actual destruction of the blood–spinal cord barrier.

The aim of my study was to further investigate this observation and offer evidence for an interaction between nociceptive stimulation and the extent of bleeding after spinal cord injuries. If nociceptive input from an associated injury contributes to the breakdown of the blood–spinal cord barrier, it could have serious implications for the recovery of the injured spinal cord. Understanding how pain impacts recovery after spinal cord injuries—and more importantly, how to prevent the effect—could eventually lead to improved prognosis for the many victims of spinal injuries.



**Figure 2.** Sections of spinal cord tissue from shocked subjects at  $\times 10$  (left),  $\times 40$  (middle), and  $\times 100$  (right) magnification. Large amounts of blood are present, and the  $\times 100$  magnification confirms the presence of red blood cells.

## Methods

Male rats were anesthetized and the spinal cord was exposed at the site of injury. A small weight was dropped directly onto the spinal cord, resulting in a moderate spinal cord injury. The experimental spinal injury closely resembles the type of injury seen in most clinical cases and serves as a relevant and controllable model for human spinal cord injuries. The injury is given in the thoracic portion of the spinal cord, which results in the loss of mobility and sensation in the lower half of the animal. Subjects were allowed to recover for 24 hours after surgery in a temperature-controlled room with easy access to food and water. They were monitored during recovery to maximize comfort and check for signs of distress.

After the recovery period, half of the subjects received 6 minutes of nociceptive stimulation in the form of electrical shock applied to the tail. The shock itself is designed to be mild enough to not cause tissue

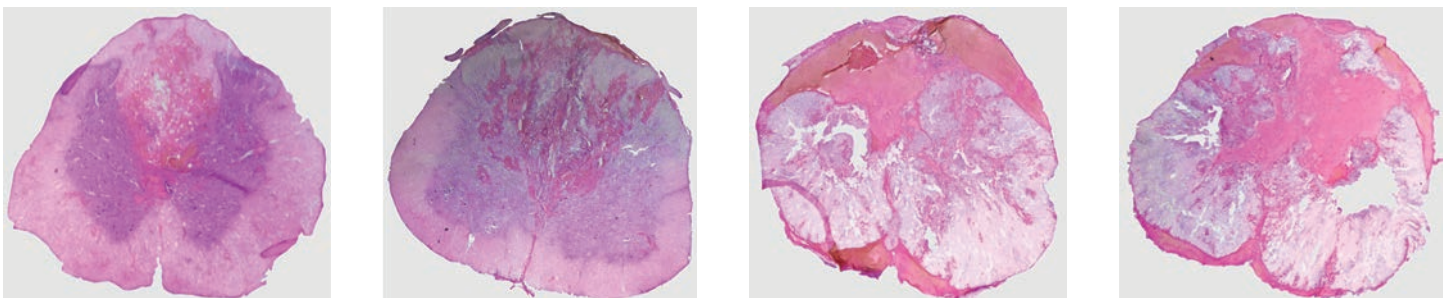
damage but robust enough to engage the nociceptive neural circuits. As a result of the contusion injury, communication with the brain is diminished, resulting in decreased experience of pain for the subjects. Subjects that did not receive noxious stimulation were simply restrained in the shocking apparatus for the 6-minute period. At 3 and 24 hours after treatment, subjects were killed and their spinal cords were collected and preserved for examination. We have shown that 3 hours is enough time for the effects of the nociceptive stimulation to manifest. A 1-cm segment of spinal cord centered on the lesion site was harvested and preserved for microscopic evaluation. The segments of lesion-site tissue were cut into 20- $\mu$ m sections by using a cryostat, a device that slices tissue ultrathinly, and mounted on glass slides. The tissue was then stained with hematoxylin (deep blue–purple stain) and eosin (pink stain), a basic histological stain that allows

for observation of gross cellular structures, and covered with a thin sheet of glass to protect the sample.

## Results

When we examined the sections of lesion tissue under a microscope, I saw distinct areas of red throughout the spinal cord. Increased magnification revealed that the red areas were made up of red blood cells (Figure 2). Also, most of the bleeding occurred in the gray matter of the spinal cord, an area rich in blood vessels. These observations offer evidence that bleeding can account for the dark red color of the protein extracts.

Several differences were apparent in comparing tissue from subjects that received nociceptive input and those that did not (Figure 3). The sections of spinal cord from subjects that received nociceptive input appear deformed and fragmented. Further, those subjects had significantly more bleeding than subjects that did not receive stimulation. These



**Figure 3.** Hematoxylin and eosin–stained spinal cord tissue from subjects that received spinal cord injuries and harmful input (right two) or just spinal cord injuries (left two) show distinct red areas of hemorrhaged blood. Painful input appears to increase the amount of lesion-site hemorrhage. Additionally, tissue from subjects that received painful input appears to have gross structural deformities.



observations support my hypothesis that nociceptive input may increase the amount of blood present at the lesion site. The presence of many red blood cells in the spinal cords of shocked subjects strongly suggests that a significant breach in the integrity of the blood–spinal cord barrier has occurred, allowing the release of blood into the lesion.

## Discussion

Every year, more than 12,000 new cases of spinal cord injury occur in the U.S. alone. The victims of spinal cord injuries often face a lifetime of reduced mobility and sensation, loss of bowel or bladder control, chronic neuropathic pain, and respiratory or cardiovascular issues.<sup>5</sup> No existing treatments can reverse the damage done by spinal cord injuries. Therefore, most therapeutic techniques center on reducing the progression of the secondary injury or building off surviving neurons. Although these methods have merit, the difficulties of recovering after a spinal cord injury still place a significant life-long burden on both the victims and their caretakers. As of now, minimizing secondary damage after a spinal cord injury remains the best way to maximize recovery.

We have shown that nociceptive input administered soon after a spinal injury occurs impairs recovery.<sup>1</sup> Although the exact mechanism behind this phenomenon is not clear, pain signals appear to cause additional inflammation and cell death during the secondary injury phase. My study gives evidence that pain signals may also contribute to lesion-site bleeding, which could play a role in the observed recovery deficit. Although a deeper investigation is needed, I hypothesize that what we are observing is akin to a positive-feedback cycle: inflammation after spinal cord injuries damages the blood–spinal cord barrier, which in turn fails to function properly and lets in harmful substances, leading to even

more inflammation in the spinal cord. Such a loop presents an attractive target for therapeutic intervention, especially in its potential to have such an impact on recovery. But many questions remain: What cellular mechanisms underlie the effect of pain signals on the blood–spinal cord barrier? How does a dysfunctional barrier lead to increased cell death? And perhaps most importantly, how can we stop this effect?

I am further analyzing the blood in the tissue. Eventually, I want to measure the amount of blood as percentage of the total area by using fluorescent imaging techniques. I am also examining the degradation and segmentation of blood vessels at the injury site to gauge the severity of blood–spinal cord barrier damage. I would also like to administer intravenous dye to spinally contused subjects to measure the degree of barrier dysfunction. Future work will aim to uncover what cellular mechanisms are leading to blood–spinal cord barrier breakdown, with the hope that doing so will improve our understanding of why pain is so detrimental to spinal cord injuries.

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“X-ray of the erect lumbar spine with a S-convex scoliosis” by Lucien Monfils is licensed under CC BY 2.0. Source: <https://commons.wikimedia.org/wiki/File:Scoliosis.jpg>.

# REACHING UTOPIA:

## *Creating Plato's Republic with Asimov's Robots*

By Lawson Hamilton

### Introduction

"Only the Machines, from now on, are inevitable."<sup>1</sup>

In the closing lines of Isaac Asimov's *I, Robot* (1950), Dr. Susan Calvin and World Co-Coordinator Stephen Berley contemplate the fate of humanity in robotic hands.

It may be science fiction now, but it could be our future. Technology is an integral part of human history, enabling both its greatest achievements and darkest moments. Until today, machines have needed intelligent users, but the exponential growth of smart technologies now forces us to confront *singularity*: "a time when machines would equal and then exceed human intelligence."<sup>2</sup> A technological singularity may seem farfetched, but a host of academics and inventors consider it inexorable. Such an event will dramatically affect every aspect of human life, from labor and the arts, to warfare and government. When a human is no longer the smartest being in the room, who (or what) will rule? That is a frightening question, but one that offers an opportunity to make a better world and, perhaps, reach utopia. This study suggests the human hierarchy of Plato's *Republic* with the artificial intelligence of Asimov's Robots.

The first fully formed utopian vision appears in the philosopher Plato's renowned *Republic* (circa 380 BCE), which also is probably the first complete work of political theory. The greatest challenge of the *Republic* is how to create Plato's practically superhuman guardians who would govern his "just city," a task even the author admits is difficult. An unwitting solution came some 2,000 years later with the publication of Isaac Asimov's *I, Robot*. Although the

novel never refers to the *Republic*, it offers a way to eliminate much of the arduousness of achieving Plato's republic by using Asimov's robots as its guardians (Figure 1).



**Figure 1.** Man and Machine. Isaac Asimov's *I, Robot* offers a means to create the guardian class of Plato's *Republic* with mechanical men. Artwork courtesy of Bailey Rogers, a graduate student at Texas A&M University.

*"When a human is no longer the smartest being in the room, who (or what) will rule?"*



## Analysis and Review

### *The Republic*

The main project of the *Republic* is to define justice. Everything, be it a person, an object, or a state, has a proper function; justice is done when that function is performed well. Much of the *Republic* is dedicated to explicating that highly structured but ideal state. Plato especially devotes himself to describing the guardians, whose members are the smallest class yet are an essential part of the city. He writes of them time and again to give readers a complete image of the perfect civil servant: “We must choose from among our guardians those men who, upon examination, seem most of all to believe throughout their lives that they must eagerly pursue what is advantageous to the city and be wholly unwilling to do the opposite.”<sup>3</sup> Producing such a class is no simple feat, and that’s why the philosopher spends a great deal of time discussing their education (Figure 2). As seen in the figure, the road to become a guardian for humans is far more strenuous, whereas robotic guardians need only be manufactured and programmed.

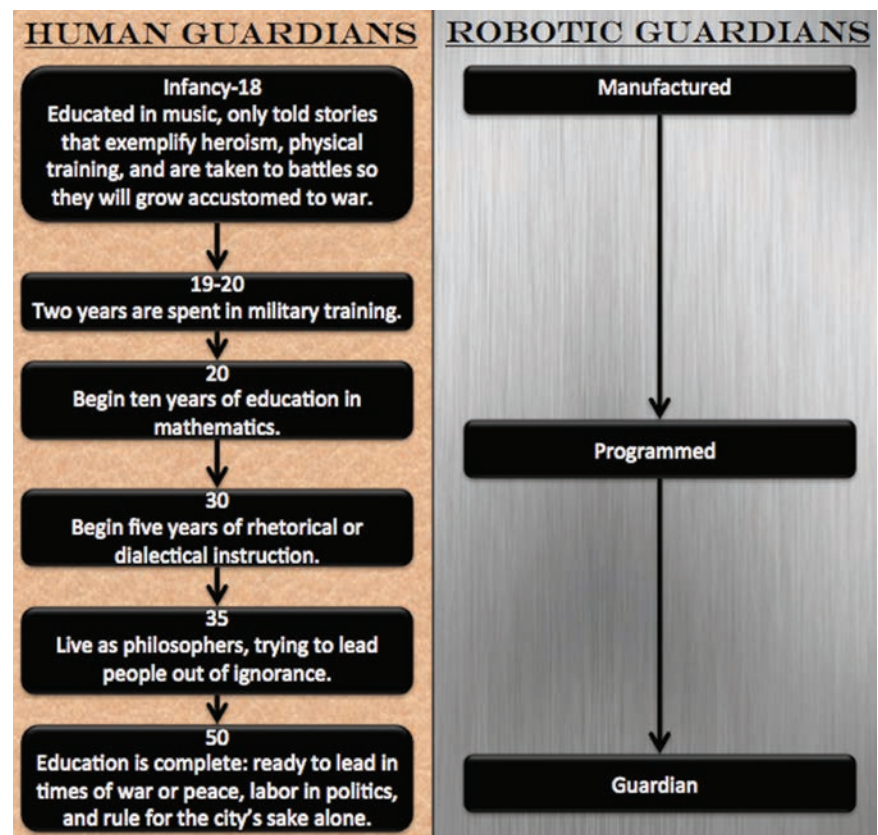


Figure 2. Man versus Machine: Education of the Guardians

The rigorous, structured, practically monastic life of the guardians (described in Figure 2) leads one to doubt that anyone would choose to be a guardian. Rather, Plato’s vision alludes to the city as a whole being happy—or *eudaemonic*, meaning fulfilled—even if the governing class is not. For that reason, most of the city’s inhabitants will also be happy. The life of guardianship is intentionally unappealing for, as Plato writes: “A city whose prospective rulers are least eager to rule must of necessity be most free from civil war, whereas a city with the opposite kind of rulers is governed in the opposite way.”<sup>3</sup> With no private interests to advance, the guardians will not pillage their citizens like tyrants nor lead them into war without good reason. Despite the difficulty of instituting his system, Plato maintains that it is possible. A state ruled by his guardians is the ideal form—and achieving ideals is no easy task.

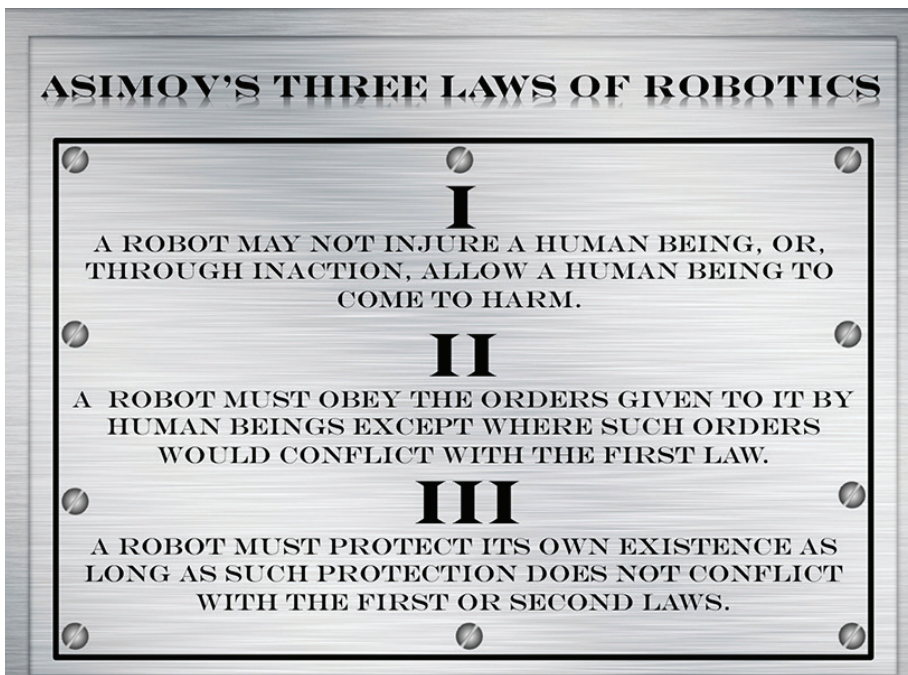
### *How Asimov’s Machines Make the Republic Possible*

A reader of the *Republic* might imagine that the guardians sound ascetic and fear that human nature is incompatible with a life like that of a guardian. Plato himself, perhaps presciently, wrote: “It’s no wonder that the majority of people aren’t convinced by our arguments, for they’ve never seen a *man* that fits our *plan*.”<sup>3</sup> Then why not remove the difficulty of working with humans by replacing them with actual robots? Plato cannot be expected to have considered robotic guardians, but in today’s world of sophisticated technology, nothing prevents humanity from considering it. The training process for robotic guardians would be appreciably simplified, increasing the possibility of achieving Plato’s utopian vision. Gone is the 50 years of education and experience previously required for guardians (Figure 2). Instruction is now a matter of programming.

### *Why Asimov?*

Why Asimov’s robots? Asimov deserves special attention simply because he was the first to predict the opportunities of modern robotics. He invested more empirical thought in his mechanical men than most science fiction writers, even considering his Three Laws of Robotics (Figure 3) as genuine options for future programming. Although the technology to create robots of Asimov’s level of sophistication has not yet been realized, history and scientific trends suggest that if producing robots with intellectual capacities akin to Asimov’s positronic brain (essentially a robotic mimic of a human brain) is possible, then it will be done.

While achieving that goal might seem implausible, the possibility of producing a highly advanced technology such as the positronic brain is not so far off. MIT-educated futurist Ray Kurzweil has devoted his career to furthering the concept of the Law of Accelerating Returns: “As order exponentially increases, time exponentially speeds up (that is, the time interval between salient events grows shorter as time passes).”<sup>4</sup> Here Kurzweil means *order* as the opposite of disorder: random events relevant to the evolutionary process. An example is the asteroid that struck Earth 65 million years ago; probably both extinguishing the dinosaurs and sparking the evolutionary development of more complex mammalian life. Kurzweil believes that explosive technological proliferation, in accordance with the Law of Accelerating Returns, will lead to singularity: today the iPhone, tomorrow the positronic brain. Research teams and even whole academies (such as the Machine Intelligence Research Institute) are devoted to the



**Figure 3.** Man's Laws for Machines. The laws are Asimov's attempt to ensure human life while preserving the robots themselves. *I, Robot* is in essence a series of short stories that explore potential challenges to the laws.

development of artificial intelligence (AI) technologies. "Researchers," fellows at the Machine Intelligence Research Institute write, "largely agree that AI is likely to begin outperforming humans on most cognitive tasks in this century."<sup>5</sup> Accumulated evidence and the collective wisdom of the world's experts in the field suggests that the emergence of robots comparable to Asimov's is not so much a question of if, but when.

## Discussion

### Challenges

#### Beware the Killer Robot

Several potential challenges confront the idea of creating Plato's guardians with Asimov's robots, perhaps the greatest of which emerge in *I, Robot* itself. Probably the most appreciable is that the robots will decide that humanity is inefficient and destroy it. That scenario might appear to be the situation described earlier from the final chapter of *I, Robot* when Coordinator Berley and Dr. Calvin discover the robots' actions against the Society for Humanity, a league of humans with antimachanical sentiments. Surprisingly, Asimov does not regard this as a prelude to apocalypse but rather as a chance to end human want and war. The machines are not killing people but are, through a complex series of coordinated actions, removing them from positions of power in which they could challenge the robotic hegemony. Only the Three Laws guarantee that relative safety—further emphasizing Asimov's significance. Robots are not necessarily quirky and helpful in the style of *Star Wars* droids, friendly like the film *Iron Giant*'s (1999) colossus, or compassionate in the manner of Disney's WALL-E. Asimov did not imagine them in this way, nor does Kurzweil deny the dangers of

*uncontrolled* robotic evolution. Without meticulously including the Three Laws of robotic programming, and even adding new ones as necessary, humanity might face a situation like that of Dr. David Bowman in Arthur C. Clarke's *2001: A Space Odyssey* (1968). In that film, a programming conflict leads HAL, the AI who runs the spacecraft, to conclude that the human crew members are hindering their own mission and should consequently be eliminated.

#### Goodbye Freedom

Also dubious is a claim Dr. Calvin makes that the machines' absolute control would end all types of economic disruption. She argues that its current cause is humanity's inability to comprehend the intricacies of economics and the human proclivity for war. The robots, understanding themselves as the best way to prevent economic dislocation, know that their own destruction is the greatest threat to humankind. Therefore, they act to ensure their own preservation for the

sake of humanity. Even so, people would have no voice in their own affairs; the machines would tell them how to be educated, where to work and live, with whom to reproduce, how many children to have, and so on. As Coordinator Berley says: "You are telling me, Susan, that the 'Society for Humanity' is right; and that Mankind *has* lost its own say in its future."<sup>1</sup> Survival and peace are at the cost of independent decision-making and thought. The same cost is required to institute Plato's republic, at least for the guardians, even with an entirely human population.

*"The inevitable rise of superintelligent technology suggests that reaching utopia is now truly possible, even unavoidable."*

#### Hello, *Homo optimus*

Kurzweil offers a potential way to circumvent this cheerless future. In *The Age of Spiritual Machines* he argues that within the 21st century computer intelligence will not only exceed human intelligence but also merge with it. This is the true meaning of *singularity*. Humans will make such heavy use of AI that the integration of humans and machines will make the two indistinguishable. A recent *Daily Mail* article about the research of futurologist Dr. Ian Pearson, which cites Kurzweil, further illustrates the concept. That article describes a human-AI merger that



will produce a superhuman called *Homo optimus* as early as 2050.<sup>6</sup> With the enormous expense of creating a singular being out of man and machine, such a process would probably be available only to a select few. An elite society it might be, but at least it would be one with more human guardians.

#### *Perhaps How Wonderful*

Two millennia ago, Plato conceived the utopian vision. Ever since, the ghost in our human machine has whispered of utopia's possibilities. Yet even Plato knew his ideal form would be nearly impossible to grasp. The inevitable rise of superintelligent technology suggests that reaching utopia is now truly possible, even unavoidable. Kurzweil, Asimov, Plato, and a score of others optimistic about the future would welcome that eventuality. As Kurzweil writes in *Spiritual Machines*: "My own view is that a planet approaching its pivotal century of computational growth—as the Earth is today—has a better than even chance of making it through. But then again, I have always been accused of being an optimist."<sup>4</sup> Some people, however, do not share his optimism or like those odds. Documentarian James Barrat warned against the dangers of such a future in a book titled *Our Final Invention: Artificial Intelligence and the End of the Human Era* (2013). He argues that intelligence is unpredictable and that the development of super-AI will entail levels of intelligence, "we cannot ourselves reach, and behaviors that probably won't be compatible with our survival."<sup>7</sup> Barrat's fears are reasonable, and he is part of a tradition of scholars who have stood athwart every attempt at utopianism, yelling, "Stop!"

That these ideas are frightening is perhaps as it should be. At the prospect of a machine-controlled future, Coordinator Berley exclaims, "How horrible!"<sup>1</sup> But Dr. Calvin replies, "Perhaps how wonderful!"<sup>1</sup> Incredible technological evolution is coming. If humanity simply allows it to happen unchecked, our future is indeed dark. Humanity must fight to control its destiny. Synthesizing Plato and Asimov offers at least one valuable way to do so. With serious research and a vigilant eye toward its protection, humanity may be able to face the future and say, "How wonderful."

#### **Acknowledgments**

This project began under the advisement of Drs. Rich Cooper and Cary Nederman in their respective classes, Science Fiction Literature and Early Political Thought. I am grateful to both for their words of wisdom, and Dr. Cooper especially for serving as my adviser throughout this process.

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**Figure 1.**  
Final installation as seen  
from the side.

# *Aequalis*

*By Carolina Pereira*

*“Once we remove that mask, we are human. We are equals.”*

I want my art to have meaning; I want it to inspire others, to strike the match of imagination and tenacity. This sculpture speaks in a way that my words cannot; being able to put my thoughts into a physical piece was invigorating. The skull symbolically represents equality, hence the title *Aequalis*, which means “equals” in Latin. My inspiration for this project was the constant pressure of being societally imposed to fit in, or inversely, the pressure to stand out. This piece reflects the strength I have as an artist to speak through colors, strokes, and shapes. It reflects the ability to influence others’, to help them see life in a way they never have before. I see in it the hopeful fire that lies in me to be an agent for change, for bettering life in the best way I know: through art (Figure 1).

The final project consists of a 3-D human skull created out of vertically layered white scrapbook paper. The final installation resembles the size of an average adult cranium. The concept behind my project was to create a 3-D object out of 2-D materials. I achieved that goal by slicing the skull in cross sections, with each section represented by a sheet of scrapbook paper, then relayering those sections to re-create the skull. So as to stay true to the color of a real skull, I chose white scrapbook paper as my medium (Figure 2). The white layered paper represents simplicity and complexity. It is simply layered paper, which remains meaningless if layered incorrectly. However, once it is structured and shaped, it gives way to the complexity of a human being.

*“Once [the paper] is shaped, it gives way to the complexity of a human being.”*

The layers are a metaphorical representation of dissecting a human skull and always finding the same result: a human being. I chose to do a colorful collage of symbols and words on the mask to emphasize our fixation with meeting the standards and expectations of society. The mask is made up of words that define profession, personality, and characteristics that encompass a person. On top of the collage of words are symbols that also represent what makes up a person’s personality, thus creating a strong visual element that contrasts against the skull (Figure 3).



Figure 2. The layers of the skull installation as seen from above.



Figure 3. Detailed view of the installation and mask composition.





# Understanding How Algal Toxins Enter the Marine Food Web

*By Jessica Gwinn*





## Introduction

Ciguatera fish poisoning is a seafood-borne illness widespread in the tropical and subtropical waters of the Pacific and Indian Oceans as well as the Caribbean. The disease, caused by a potent neurotoxin called ciguatoxin, is produced by microalgae in the genus *Gambierdiscus* and accumulates in reef fishes. Researchers recognize the disease as the most common foodborne disease related to fish consumption worldwide.<sup>1</sup> Despite this, little is known about the environmental distribution of ciguatoxin before it is ingested by humans. This study explores the movement of the toxin into Caribbean coral reef food webs. Particularly, I focus on factors that may affect toxin accumulation within herbivorous reef fish. Fish in lower levels of the food web represent a critical point of entry into food webs that may direct the fate of ciguatoxin in reef ecosystems.

Humans contract ciguatera fish poisoning when they consume fish contaminated with ciguatoxin. More than 400 fish species have been associated with the disease; the most common include grouper, barracuda, snapper, jack, and mackerel. The neurotoxin is undetectable by sight, taste, or smell and is extremely stable; because of these characteristics, cooking or freezing cannot eliminate the toxin from seafood before consumption. Ciguatoxin binds to and prevents the closure of sodium channels on nerve cell endings critical in cell signaling. This results in prolonged activation of neurons, which impedes the repolarization of sodium channels, ultimately leading to cell death. Acute poisoning in humans results in a variety of severe gastrointestinal, neurological, and cardiovascular symptoms that can last for several months. According to researchers, ciguatera fish poisoning affects approximately 50,000 people in the U.S. annually; a broader estimate of as many as 500,000 cases per year has been suggested due to under-reporting and under-diagnosis.<sup>2,3</sup>

The microalga (*Gambierdiscus* spp.) that produces the nontoxic precursors of ciguatoxin is widespread throughout the tropics and lives on the surfaces of algae and corals. The toxin precursors enter the marine food web as they are consumed by herbivorous fish feeding on and around algae and corals colonized by the toxic microalgae. When predatory fish consume these reef herbivores, the fat-soluble toxins continue to be transferred to higher levels of the food web. Metabolism of the toxin precursors within fish results in the biotransformation of the initially nontoxic precursors into a potent neurotoxin. In this way, ciguatoxins are spread throughout marine food webs, where they may affect ecosystem dynamics and accumulate in reef fish targeted for human consumption. The complex biochemical pathways of the toxin complicate prediction of human ciguatera fish poisoning outbreaks and make the disease harder to manage.

Recent studies have shown that the incidence and geographic distribution of ciguatera fish poisoning are increasing, especially as fish from disease-endemic areas are exported to regions in which the disease doesn't naturally occur.<sup>4</sup> Furthermore, the distribution and abundance of the microalga that produces the toxin precursors are projected to shift into higher latitudes as a result of rising ocean temperatures associated with global climate change.<sup>5</sup> The economic and human health impacts combined with the potential to compromise seafood security in some regions, such as the highly productive Gulf of Mexico, make ciguatera fish poisoning and the food web dynamics of the toxin important topics of study.

The transfer of toxin precursors from algae to herbivorous fish represents a critical point in the fate of the toxin because the fish that become contaminated at this level of the food web determine which higher-level fish are exposed to the toxin by feeding on toxic fish. I studied two families of herbivorous fish dominant in Caribbean reef communities to understand which factors may contribute to toxin movement in lower levels of the food web. Ocean surgeonfish and parrotfish consume similar food sources: organic debris from the decay of microorganisms as well as algae that live on macroalgae and corals. However, these fish feed in different ways. Ocean surgeonfish selectively graze on soft fleshy algae or turf algae. They discreetly pick off pieces of macroalgae and simultaneously consume associated organisms growing on the algal surface. Parrotfish, however, use beak-like teeth and specialized teeth in their throats to remove large chunks of calcareous algae or coral. They extract associated algae and associated organisms in the process of grinding up the coarse fragments of the coral.<sup>6</sup> Noting these unique feeding strategies inspired me to investigate the following question: Do the differences in feeding strategies between ocean surgeonfish and parrotfish influence the bioaccumulation of ciguatoxin precursors in their tissues?

## Methods

Ocean surgeonfish (*Acanthurus bahianus*), stoplight parrotfish (*Sparisoma viridae*), redband parrotfish (*Sparisoma aurofrenatum*), and striped parrotfish (*Scarus iseri*) samples were collected from key field sites in St. Thomas, U.S. Virgin Islands (Figure 1). St. Thomas is an area deemed “hyper-endemic” because of the high incidence of ciguatera fish poisoning, an estimated 12% illness rate per capita in the local island community.<sup>7</sup> Both field sites are protected, nearshore reef areas on the southern, leeward side of the island and are therefore protected from northerly winds. Following collection by spearfishing, samples were transported frozen and stored at the Dauphin Island Sea Lab on Dauphin Island, Alabama, where I conducted my research.

First, I carefully identified and assigned species to each fish sample since shipping and storage can change characteristic color markings. I then used chemical extraction techniques to isolate ciguatoxin from fish samples to assess the relative toxicity of each fish. I took small (1g) subsamples of muscle tissue from the base of the dorsal fin of each fish. Next, I homogenized the tissue in acetone to extract the toxin and other organic compounds. I isolated the toxin by using chemical separation steps depending on chemical properties such as polarity (electric charge) and degree of solubility in fat. This chemical separation process is based on the principle of “like dissolves like” to isolate a compound of interest. By dissolving the samples in chemicals with different properties, I could predict where the toxin would appear. After removing proteins and other interfering components from the sample, I dried the samples and resuspended the toxin in cell culture medium for later use in a cell-based cytotoxicity assay.

I tested the fish samples for ciguatoxin by using a sodium channel-specific cytotoxicity assay. A cytotoxicity assay is literally “a test of toxicity to cells” that measures the extent of cell mortality when exposed to a compound of interest, which eliminates the need to use live animals. I maintained a cell culture of mouse neurons in media that was replaced often to ensure optimal cell condition during their use in the assay. Since ciguatoxin targets sodium channels, the cytotoxicity assay evaluated the extent of cell death specifically caused by interference with sodium channel function. Therefore, for each fish sample to be tested, I prepared cells where ion channels were sensitized and cells that were nonsensitized to confirm that any cell death observed resulted from the specific sodium channel activity of the toxin rather than a nonspecific effect (which would also kill nonsensitized cells). Since the cells used in this study have lost their sodium channel activity after many generations in culture, they are initially unaffected by ciguatoxin. Exposing cells to reactivating agents effectively activates the sodium channels and makes them sensitive to the neurotoxin for use in the cytotoxicity assay. Applying

a sodium-channel toxin such as ciguatoxin is expected to kill sensitized cells in a dose-dependent manner whereby exposure to higher concentrations of toxin should cause a greater extent of cell death. Conversely, the toxin should not affect nonsensitized cells.

Once sensitized and nonsensitized cells were prepared, I applied my fish tissue extracts at an equivalent dose based on the amount of original tissue sampled from the reef fish. For example, a 1 g tissue equivalent dose would be equal to the amount of toxin extracted from the entire 1 g sample of tissue; a 20 mg tissue equivalent dose corresponds to the amount of toxin in only 20 mg of that tissue sample. In this study, I screened samples first at a 20 mg tissue equivalent dose and then at a higher 86 mg tissue equivalent dose.

After treatment with fish tissue extracts, I measured cell viability with a colorimetric test using a dye that changes color as it is taken up by living cells. The amount of dye taken up is directly related to the number of living cells and can be measured with spectrophotometry.

Spectrophotometry is used to determine the concentration of a substance in a solution according to how much light is absorbed or transmitted through the solution. Since cell viability is inversely proportional to cell death, the measurement of cell viability is essentially a measure of the extent of

mortality caused by exposure to the toxin. Comparison of cell viability of sensitized cells with that of nonsensitized cells allows for an estimation of how much cell mortality results specifically from the interference of sodium channel function and therefore enables the detection of ciguatoxin. I considered samples to be “ciguatoxic” when they reduced the viability of sodium channel-sensitized mouse neurons by 75% in relation to the viability of the nonsensitized cells.

## Results

Initial screening was performed at 20 mg tissue equivalent doses for each sample. Only three samples of the 84 total fish assayed (3.57%) showed detectable cell mortality due to the presence of sodium channel-specific toxins. All the fish with detectable ciguatoxin activity at this dose were ocean surgeonfish.

On the basis of these data, samples were screened again at a higher 86 mg tissue equivalent dose to improve the toxin detection limits in the fish samples. At this dose, 52 samples of the total 84 fish assayed (61.90%) showed detectable toxicity to cells. Of the toxic fish, 39 (75%) were ocean surgeonfish, whereas the other 13 (25%) were parrotfish (Figure 2).

## Conclusion

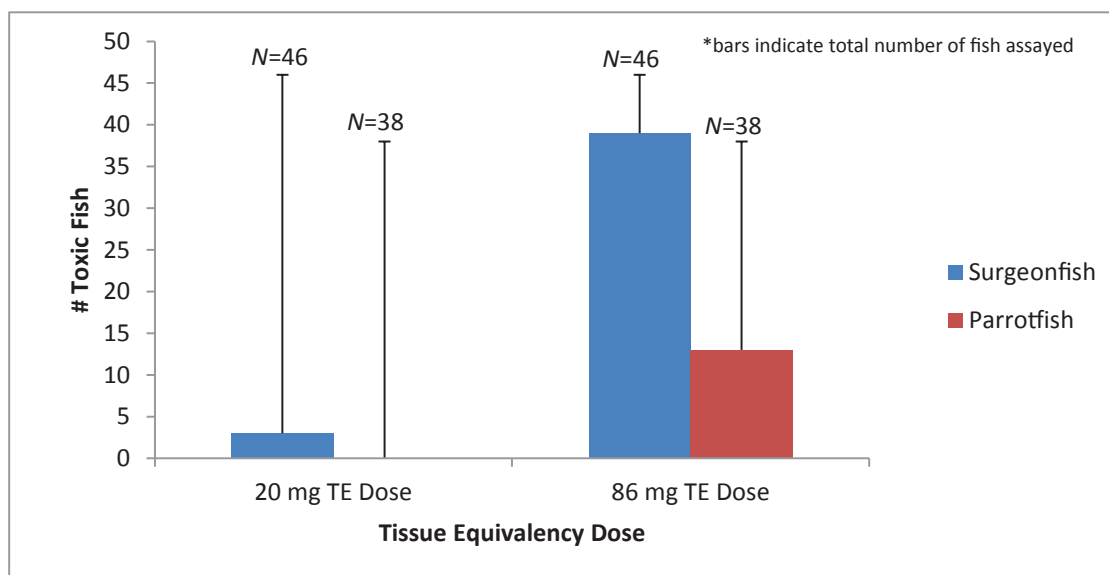
This study shows that ocean surgeonfish may be more likely to accumulate ciguatoxin precursors than parrotfish because they constitute a greater portion of the fish with detectable toxin activity in the samples collected from

**“Researchers recognize the disease as the most common foodborne disease related to fish consumption worldwide.”**





**Figure 1.** Species included in this study: (A) ocean surgeonfish (*Acanthurus bahianus*), (B) stoplight parrotfish (*Sparisoma viridae*), (C) redband parrotfish (*Sparisoma aurofrenatum*), and striped parrotfish. (*Scarus iseri*) (D).



**Figure 2.** Number of herbivorous reef fish (surgeonfish vs. parrotfish) with detectable ciguatoxin activity during cytotoxicity screening at 20- and 86-mg tissue equivalent doses.

**Figure 1A.** “Ocean Surgeonfish *Acanthurus bahianus*” by Paul Asman and Jill Lenoble is licensed under CC BY 2.0. Source: <https://www.flickr.com/photos/pauljill/3471817497>.

**Figure 1B.** “Parrotfish” by DJ is licensed under Adobe Stock Standard License. Source: File #48882135.

**Figure 1C.** “Redband Parrotfish *Sparisoma aurofrenatum* Initial Phase” by Paul Asman and Jill Lenoble is licensed under CC BY 2.0. Source: <https://www.flickr.com/photos/pauljill/3476125891>.

**Figure 1D.** “Striped Parrotfish *Scarus iseri*” by Paul Asman and Jill Lenoble is licensed under CC BY 2.0. Source: <https://www.flickr.com/photos/pauljill/4657126126>.

St. Thomas, U.S. Virgin Islands. This finding suggests that interspecific feeding differences do play a role in toxin entry into the marine food web and thus the transfer of toxins to higher-level predators, including humans. Alternatively, the prevalence of toxins in surgeonfish in these sites may be due to a substrate preference by the microalgae that produce ciguatoxin precursors (*Gambierdiscus* spp.) for sea grass as opposed to corals, which would preferentially expose surgeonfish to the toxin precursors. Furthermore, parrotfish consume digestible material from the large chunks of coral or calcareous algae they grind up before excreting the rest as excrement of sandlike consistency. It may be that parrotfish rapidly excrete a large proportion of the consumed algae, reducing the uptake of associated microalgae. This might explain the less frequent incidence of ciguatoxins in the parrotfish observed in my study. The results warrant further investigation into substrate preference by the microalgae in the genus *Gambierdiscus* and how feeding strategy may affect the uptake of the toxin precursors by herbivorous fish.

A preliminary study reported whole-fish extracts as being more ciguatoxic at lower doses than the doses administered in this study, in which I tested toxin extracted from muscle tissue alone.<sup>8</sup> Extracting toxin from whole fish may allow for a more accurate estimation of the amount of toxin a fish is likely to pass on to higher feeding levels because it includes all the toxin present in muscle, fat, skin tissue, and the digestive tract. The concentration of toxin in skeletal muscle indicates the accumulation of the fat-soluble toxin in fish; the results found in this study suggest a relatively low rate of accumulation in the herbivorous fish tested. Since whole-fish extracts were more toxic than extracts from skeletal muscle only, herbivorous fish may rapidly eliminate or detoxify the toxins through their gut. The advantage of testing skeletal tissue alone is that it provides a better estimate of human health risk from consumption. Future research should focus on how fish compartmentalize ciguatoxin precursors into various tissues as well as understanding accumulation and elimination rates of the toxin in fish. Such research would offer a better picture of possible transfer routes to higher levels of the food web and, ultimately, humans.

Despite ciguatera fish poisoning's considerably high rate of annual incidence and broad distribution, the lack of effective prediction and management strategies shows a need for further research into the origin and transfer of the disease. The need for this information is especially pressing in light of increased trade and global climate change, which already has allowed range expansion of tropical species to more temperate regions.<sup>9</sup> Although this study offers some insight into the presence of ciguatoxin in different herbivorous fish from St. Thomas, U.S. Virgin Islands, much more remains to be discovered with regard to the food web dynamics of ciguatoxins and how this influences human exposure to ciguatera fish poisoning.

## Acknowledgments

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Foundation Research Experience for Undergraduates Program, the National Oceanic and Atmospheric Administration Ecology and Oceanography of Harmful Algal Blooms. Special thanks to Dr. Alison Robertson, the principal investigator on this project, for her guidance and support throughout my internship. I also thank Dr. Will Patterson for assistance with reef fish identification and Katie Baltzer, Brian Klimek, Emma Vaters, Molly Thistle, and Diana Cordero for their help and support with this project.

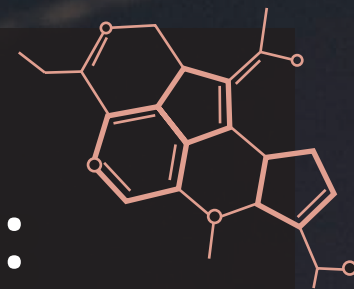
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# A Picture Is Worth a Thousand Numbers:

## A Software to Revolutionize How Biological Images Are Quantified



*By Ana Chang-Gonzalez*

### Introduction

Everyone knows the saying “a picture is worth a thousand words”—but what if there is no person or method to look at the picture? Someone simply looking at an image of a person’s face can infer several qualitative characteristics about the person, such as his or her race, sex, and age. By contrast, a computer simply records the image file as a bunch of tiny squares called pixels. Each pixel is a certain color; thousands of pixels of different colors form what we see as an image. To analyze a face, a computer would have to recognize the components buried in a sea of pixels: a face is generally round, containing two semicircular objects (the eyes) lying on the same horizontal line and two near-rectangular objects (the nose and mouth) that are perpendicular to each other along the midplane of the face.

A need exists for a software that can extract numerical data from hundreds of images, quickly and

**“Snapchat can change your eye color, place a hat or dog ears on your head, or add makeup... This effect is...what we want from a bioimage analysis software.”**

accurately. A new software, called Computer Aided Feature Extraction (CAFE), was developed in Dr. Wonmuk Hwang’s laboratory in the Biomedical Engineering Department at Texas A&M to achieve this aim.<sup>1</sup> CAFE’s main function is to build computationally useful models of biological structures that can ultimately supplement and enhance biological research.

### Background

#### *Many Images, No Way to Analyze*

The term bioimage informatics has gained prevalence in the scientific community as imaging capabilities expand at a drastic pace. The term refers to processing images of biological content, such as tumor cells or a zebrafish embryo.<sup>2</sup> With the advent of increasingly sophisticated microscopes that can capture anything from macroscopic organisms to nanoscale proteins, the usage of computational software, such as CAFE, is pushing the boundaries of traditional methods for biological research.

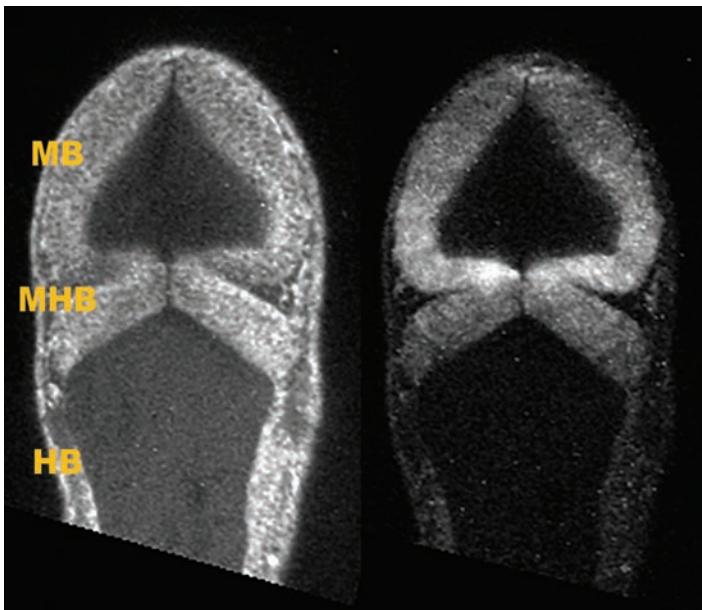
As an example of the power of automation, think of Snapchat. Someone looking at a face can determine certain qualitative information, but what about being able to measure distances and form a

map of the locations of major features to add to the picture? A single person going through hundreds of portraits to get such measurements would take multiple hours, yet a phone app can do it in a few seconds per face by building a network that maps major features. Using face mapping, Snapchat can change your eye color, place a hat or dog ears on your head, or add makeup. The app processes characteristic features, such as the eyes, mouth, and nose. It uses these feature to find the size and shape of the circular face and map it, thus creating a template on which to add all sorts of fun details.

This effect is similar to what we want from a bioimage analysis software. Forming a comprehensive analysis of an image can be a time-consuming process. With high-resolution microscopes, a researcher may process hundreds of detailed images but only realistically be able to analyze a couple. As for bioimages, an image may show key structural differences between a cancer cell and a normal cell that the naked eye might miss.

#### *Different Images, Different Requirements*

The big question for developing any all-encompassing image processing software is the wide range of



**Figure 1.** Raw images of embryonic zebrafish brain; autofluorescence (left), *wnt1* expression (right). Anatomic regions imaged are midbrain (MB), hindbrain (HB), and midbrain–hindbrain boundary (MHB). Image courtesy of H. Gibbs and A. Yeh.

bioimages, imaging equipment, and information required from each image as with detecting cancer for example.

On the macroscopic level, a scan of a brain can show rough internal structures without the need to physically slice the person’s brain. In this particular type of brain scan, dense structures, such as a tumor or the bones of the skull, appear brighter than soft tissue, such as brain matter. Using such an image, a clinician can quickly and easily detect a tumor or other abnormal growth. In this case, we would need the software to “see” a bright mass amid darker structures and locate the potential tumor.

On a submacroscopic level, clinicians can obtain a tissue sample to diagnose certain cancers, such as skin cancer. Typically in cancerous tissue, the shape of cells changes and the total number of cells within that tissue significantly increases. These anomalies are visible under a microscope. In order to use a software to analyze a tissue sample, we need the software to “count” the number of cells present within the sample as well as verify any changes in cell shape.

On the microscopic level, the presence of a particular gene expression can be a strong indicator for the development of cancer.<sup>3</sup> Since many cancer genes are developmental, we can better understand how cells become cancerous by studying the role of those genes during normal embryonic development. By marking gene expression, scientists can determine when and where during development the gene is expressed and look at the behavior of the cells that express it. Understanding a gene’s normal role in development

can help predict what role that gene may have in causing cancer later in life. In this case, the software would need to “differentiate” an abnormal gene expression pattern and “decide” whether a particular gene expression indicates tumor growth.<sup>3</sup>

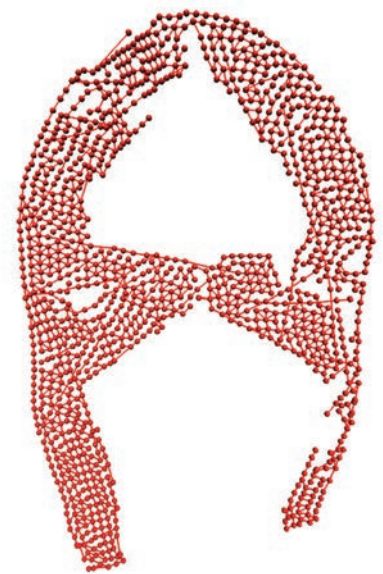
A common technique is to use fluorescent properties to study gene expression. A single embryonic zebrafish brain can be imaged by using the natural glow from the cells in the brain (Figure 1, left). A different channel of the same sample can show green fluorescent protein (Figure 1, right). This protein reports the expression of a possible cancer-expressing gene.<sup>4</sup> Studying the expression of such a gene during embryonic development is vital to understanding stem cell fate in developing and adult tissues, thus helping determine how mutations lead to cancer.<sup>5</sup> Using CAFE, we can better differentiate normal from disease-causing gene expression.

### *Current Standards*

Several readily available commercial software products can be used to analyze bioimages, such as MATLAB and ImageJ. Although both MATLAB and ImageJ are useful platforms, they usually require a tedious amount of manual user input to perform certain functions, and they are not well-suited for constructing computerized models or for automatic feature extraction from bioimages.<sup>2</sup>

### **CAFE Software**

CAFE is a stand-alone program designed to build computational models of bioimages and get quantitative information from an image.<sup>1</sup> Many current tools for bioimage analysis work on either raw or preprocessed bioimages, meaning an image is represented by pixel intensities all the way through the analysis; however, CAFE works in a much simpler manner. CAFE keeps only pixels above a certain intensity value, a practice called initial thresholding. Initial thresholding simplifies the image and makes it easier for the program to manipulate the image.



**Figure 2.** Resultant ball-and-stick model of autofluorescent-labeled embryonic zebrafish brain.

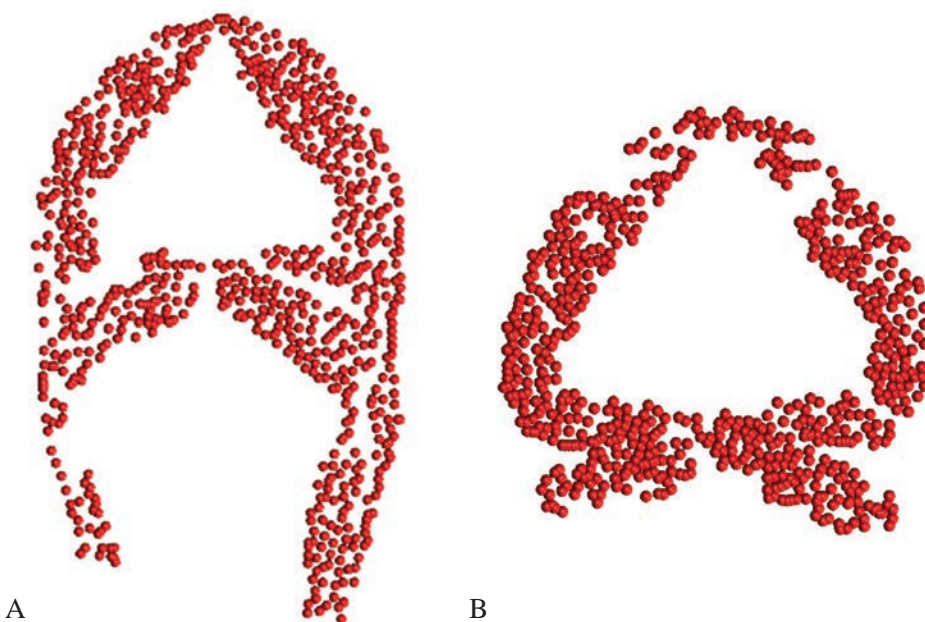


**“CAFE easily performs these calculations for several images of zebrafish embryos, finding multiple measurements at a time—a process that would be exhausting if done by hand.”**

The image is then represented as a binary format: bright pixels have a value of 1, and dark pixels have a value of 0. In CAFE an image is a grid of 1 and 0 values, which is then used to build a ball-and-stick model of the image (Figure 2). To identify where balls are in the image, the researcher defines an area, or window size, of several pixels. If more than half the area is filled by pixels with a value of 1, a “ball” is placed that is the size of the area. CAFE scans the entire image to place balls in the locations that match this criteria. When a user needs to model a contour of the image, such as the boundary line, CAFE runs a separate algorithm that connects the balls with lines, or “sticks.” Thus, the model is represented as a ball-and-stick structure, similar to those seen in macroscopic bridges or large-scale structures modeling chemical molecules. Such representation simplifies mathematical calculations needed to perform quantitative analyses.

The general structure of CAFE is a main program file with several subfiles. The main program file determines what actions the software should perform. Each function has a keyword that triggers its execution with necessary function parameters listed after the keyword. The software is told whether the image is a 2-D or 3-D stack, at what threshold the original picture should be filtered, which techniques to use for assigning the ball-and-stick model, and what analysis functions to perform on the processed image. After processing, the image is written to a coordinate file. The processed image is viewed using Visual Molecular Dynamics, a program for modeling and visualization.<sup>6</sup> Extracted information, such as quantitative measurements, is written to separate text files.

Once the overall structure of CAFE is in place we validate the software by processing bioimages representative of the common needs of scientists.



**Figure 3.** CAFE output of embryonic zebrafish brain; autofluorescence (A, left), gene expression (B, right).

### *Calculating the Numbers*

CAFE has been in development for 4 years by Dr. Wonmuk Hwang and can analyze patterns in collagen networks, the major building blocks of the body.<sup>1</sup> I have been using the software for the past year to analyze bioimages of zebrafish embryos and adding functions to locate certain major features, including structural components or fluorescence-labeled gene expression.

My current project is to analyze the expression of a particular gene in the embryonic zebrafish brain. We chose zebrafish embryos because of accessibility to test images, ability to validate 2-D and 3-D image analysis functions, and utility of the uniquely symmetric structure of an embryonic brain to refine software functionality. Using CAFE, I processed the sample images provided (Figure 1) and visualized the resulting ball-and-stick model (connecting sticks not imaged) for both the autofluorescence (Figure 3A, left) and gene expression (Figure 3B, right). These outputs show how the software recognizes the varied intensity distribution of an image and marks (by placing the red “balls”) components of interest. Using both the original image and processed output, I can see that at the developmental stage represented, this gene’s expression is concentrated around the midbrain–hindbrain boundary. Using this model, I can measure the distribution of gene expression, such as the level of expression along the middle axis of the image. CAFE easily performs these calculations for several images of zebrafish embryos, finding multiple measurements at a time—a process that would be exhausting if done by hand.

One parameter needed to represent the distribution of the gene is the main axis of symmetry of the image. Calculating an equation for the axis line will allow us to ask questions about the location of gene expression, as well as map and compare two similar images. Since CAFE converts a pixel image into balls with a specific location represented as a point on a coordinate plane, we can take advantage of the familiar setup of points to calculate the line representing the main axis. However, using mathematical calculations that incorporate coordinate values to determine a line of best fit through the major axis is inadequate for oddly shaped images. My next step is to develop an algorithm to accurately determine the centerline equation for a stack of images.

### Conclusion

CAFE is a useful software for many biological research needs that can process 2-D and 3-D images, model structures, and obtain useful quantitative information. The major strength of the software comes from its ability to automate processing. Thousands of genes are involved in physiological events; if we want to understand how they all work, we need to analyze an insurmountable number of images. Doing so would take a great deal of time and effort with current processing methods—but with this new software, the process is simplified.

The next challenge in our work is to add more built-in functionality according to research needs, validate and refine the software, and make it user-friendly. With this imaging software, we have a key method of extracting all the numbers, data, and information that a bioimage contains, rendering bioimages worth a thousand numbers.

### Acknowledgements

I thank Dr. Wonmuk Hwang for allowing me to take part in the

development of his software as well as for his mentorship and guidance throughout the project. I also thank Dr. Alvin Yeh and Dr. Holly Gibbs for supplying the images we need for testing CAFE, Dr. Arne Lekven for supplying the zebrafish for imaging, and the graduate students in Dr. Hwang's lab for helping with my projects.

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**"The major strength of the software comes from its ability to automate processing."**





# Bridging the Transatlantic Divide: Public Receptivity of Genetically Modified Products

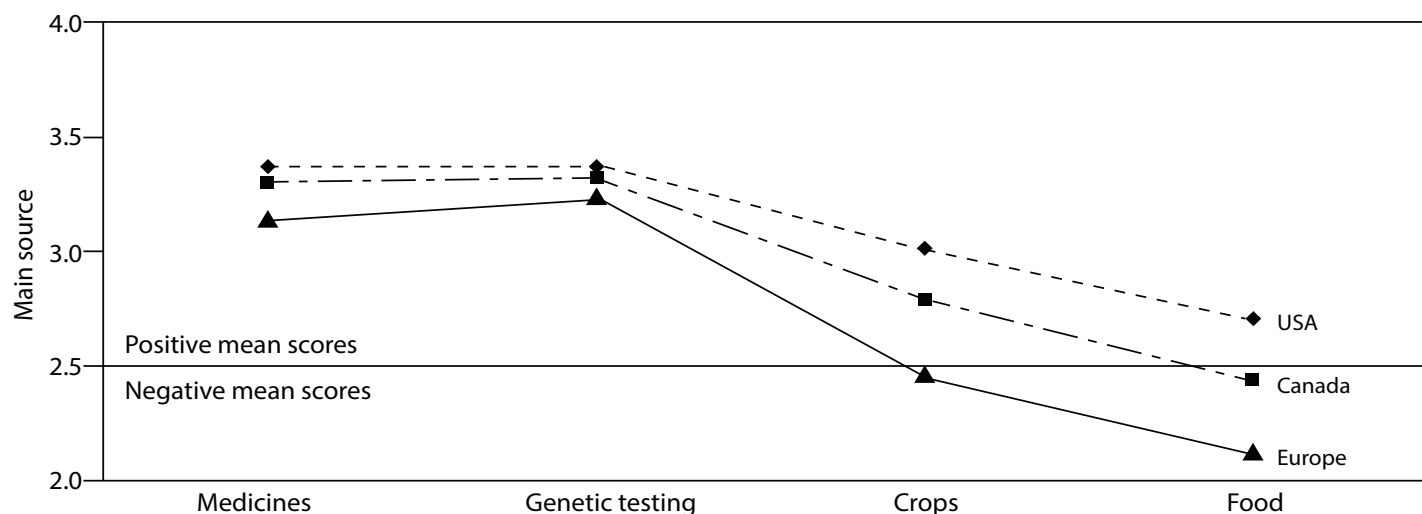
*By Hunter Greer and Jill Palmer*

**T**he “transatlantic divide” refers to the discrepancy between the acceptance of genetic engineering in the United States and Canada and the widespread rejection of it in the European Union, especially with regard to the safety and desirability of genetically modified food. Genetically modified food comes from crops or animals that are naturally occurring food sources—but that are engineered to contain or exclude genes that result in pest resistance or increased nutritional value. This study explores the intricacies surrounding the transatlantic divide as well as investigates and examines the political, organizational, and rhetorical processes through which it is sustained. The long-term goal of our research is to develop communicative strategies that might bridge the divide, and moderate this intractable conflict to create economic alliances and mend the U.S./Canada–EU trade dispute.

## Background

Genetic engineering is a technology used to alter selected genes for the purpose of creating a desirable characteristic.<sup>1</sup> This technology can remove, relocate, or add genes to individuals within or across species. Recent surveys have documented popular attitudes toward this technology in the U.S., reporting that approximately 75% of Americans believed that biotechnology would provide direct benefits in the upcoming years.<sup>1</sup> Conversely, a European Commission survey found that as many as 95% of EU residents rate genetically modified foods as potentially unsafe and lacking benefits, a rate that has steadily been increasing for the past 15 years.<sup>2</sup>

People in favor of genetic engineering technologies allege that the features of genetically modified organisms (GMOs), specifically crops, can offer considerable benefits



**Figure 1.** Surveyed support for four applications of biotechnology. Main source is a measure of support gauged from interviews with residents of each respective country (1 being the most opposed and 4 being the most supportive). Adapted from Gaskell and colleagues.<sup>3</sup>

to both consumers and producers. The first generation of genetically modified crops reduces costs for producers, creating savings that may trickle down to the consumer.<sup>1</sup> In particular, crops are modified to be more resistant to drought or disease to combat field losses; thus, crop yields and production gains increase. Scientists believe this technology could imaginably trigger a green revolution, ultimately alleviating malnourishment and starvation in previously unsustainable communities.<sup>1</sup> Moreover, crops that express herbicide tolerance and insect resistance genes can improve environmental conditions by essentially eliminating the need for harmful pesticides and herbicides. The first generation accounts for most genetically modified crops now on the market. The rhetoric of biotechnology companies has predominantly been intended for producers and largely ignores consumer interests.<sup>1</sup> This initial marketing tool is one the sector may regret because consumer pressure to abandon genetically modified crops is growing.<sup>1</sup> Supporters now face the challenge of promoting consumer benefits and relevance. The second generation of genetically modified crops will have more direct positive effects on consumers. The new generation will enhance nutrient value and reduce undesirable components, such as trans fats, that can affect one's health. The companies hope this will result in increased consumer support. Although some of these crops have started to be approved for commercialization, many products are awaiting approval.

Disapproval of the technology in Europe is often derived from consumer concerns related to potential environmental impacts, food safety, and socioeconomic implications.<sup>1</sup> Opponents raise questions regarding the safety of consuming such crops, speculating that the antibiotic resistance of GMO crops may transfer to microorganisms in consumers' guts. Also, opponents are suspicious that the technology will lead to the development of resistant weeds and insects and will adversely affect species that are not the targets of the technology, resulting in decreased wildlife biodiversity. Even though only minimal scientific evidence links human health issues with the consumption of GMOs, one can argue that the technology's broad capabilities can be used for harmful purposes. Despite the compelling scientific data in favor of biotechnology, adversaries also raise arguments related to the ethics of genetic manipulation itself.<sup>1</sup> In addition, some critics propose that the technology will have detrimental effects on small and local farmers as a result of monopolized companies such as Monsanto.<sup>1</sup>

The transatlantic divide is critical because this intractable difference between the U.S. and Europe can result in a significant economic impact and put international relations and political affairs at stake. Although sustainability and economic efficiency are of the utmost importance in the U.S., human public health and environmental awareness are more prevalent issues in Europe, which is a concerning discrepancy in the perception of consumer safety.



## Methods

The various attitudes toward biotechnology in the U.S. and the EU are the result of specific industrial structures, cultural assumptions, and political structures that foster receptivity or skepticism. To clarify the rhetoric that supports each ideal, this study analyzes and compares the U.S. and EU.

### *Industrial Structures*

Profound implications link differences in policy and regulation with the development and sustainability of the transatlantic divide. Regulatory agencies in the U.S. and Canada seem to better accommodate research and development (R&D) in biotechnology than the agencies in Europe.<sup>3</sup> Governments in the U.S. and Canada have been influential in the advancement and expansion of biotechnology research, gaining support from agencies such as the National Institutes of Health and the U.S. Department of Agriculture.<sup>3</sup> Likewise, collaboration and integration among various sectors (e.g., academia, scientists in the private sector, industry, and government) have contributed to the success of genetically modified technology research in the U.S.<sup>3</sup> This cooperative effort combined fundamental research with clinical research and applications,<sup>3</sup> resulting in the success of small corporations in the industry. These corporations developed extensively, attracting the interest of venture capitalists whose investments caused accelerated regional growth in the commercialization of GMOs.<sup>3</sup> Because research often drives policymaking in the U.S. and political structures are significantly influenced by a large industry presence, consumer opposition is not a barrier to GMO commercialization in North America.

Conversely, poor collaboration among scientific institutions, key individuals, academia, and the industry has led to stagnant and restricted R&D in Europe. Despite the European Commission's attempts to promote the expansion of research in biotechnology and improve collaborative efforts among various factors, the structural weaknesses of the research led to little development of GMO-based industry.<sup>3</sup> The significant outcomes of these organizational issues are diminished R&D investments and hindered innovative developments in biotechnology.<sup>3</sup> The weak collaborative support system has discouraged financial support from venture capitalists.<sup>3</sup> Because of this, European policies are not considerably driven by research, resulting

in political structures that are facing a nonscientific audience that consists largely of consumers.

Many research studies show that the evidence surrounding the first generation of genetically modified crops is clear, consistent, and outwardly appealing to the industry, but there is often a perceived lack of relevance to the consumer. Hence, policy toward biotechnology is speculated to be more favorable when there is a greater industry presence, as in the U.S. Since funding in Europe is limited, and nearly all biotechnology research takes place in North America, the GMO debate is halted. Although further commercialization of second-generation genetically modified crops will appear to gain more optimism from consumers, breaking down the existing and culturally rooted barrier of opposition that remains in Europe will be difficult.

**“If the transatlantic divide is not narrowed soon, it will probably never be alleviated.”**

### *Comparative Cultural Assumptions*

Different cultural assumptions alter audience receptivity of genetic technology in regards to food products. Europe looks at the “Americanization” of food products with great skepticism since food is an intimate product associated with morality and therefore susceptible to greater scrutiny regarding its purity.<sup>4</sup> European ideology has created an identity for food in each respective region. In the U.S, food is an economic commodity, whereas the EU retains cultural identity in which each ingredient embodies the social fabric of the various regions.<sup>3</sup> This attitude is especially evident in the way Europe views American agriculture as an economic entity with greater concern for profits and efficiency for farmers than for the quality of the food itself.

Another cultural assumption is the reverence for environmental protection. For Europeans, the thought of environmental mindfulness is associated with the image of “farms and farming,”<sup>1</sup> partly because many of the farms are local with respect to European cities. Therefore, European culture is intimately tied to the idea of preserving farming and rural life.<sup>4</sup> Conversely, American agriculture is a “highly mechanized and capital incentive,” occurring mainly outside highly populated places.<sup>4</sup> The value placed on technological innovation is another important difference between the regions. Optimism drives

technological development in the U.S. because the desire for progress and its advantages trumps caution. This drive for innovation is met with the public confidence in science. Alternatively, residents of the EU are more suspicious and pessimistic about the value of technology, so they tend to “err on the side of caution.”<sup>4</sup> They also consider potential adverse effects, especially within the realm of public health and environmental influences. In the United States, new products do not result in a label stating they have been genetically modified unless the products are not substantially equivalent to the original food product. This reactive approach differs from the European ideal in which all scientific innovation is regarded as new and requires more preventive investigations and scrutiny.<sup>4</sup>

#### *Political Entities and Their Effects on GM Receptivity*

Europeans’ historic opposition to genetically modified technology was exacerbated by the 1996 outbreak of mad cow disease.<sup>4</sup> The effect of the crisis increased because the British government announced that beef was safe to consume, claiming “[bovine spongiform encephalopathy] was not transmissible from ruminants [cattle] to humans.”<sup>4</sup> This blatant withholding of accurate information damaged public trust.<sup>4</sup> Thus far, the U.S. has not experienced any outbreak of this magnitude, which could alter the public’s belief in the safety of GMO technology. Although blaming this single crisis or others that occurred across the EU for the rejection of GMO technology is not reasonable, the exposure of government flaws did not aid the transparency of information governing the technology. GMO regulation in the U.S., conversely, is inherently transparent because of the legal framework, evident by “sunshine laws,” which require public bodies to hold their meetings in public, and “freedom of information” legislation, which allows individuals or organizations to access additional administrative files.<sup>3</sup>

Political entities also retain some responsibility for promoting or opposing genetic technology. In the EU, the Green Party and activist groups address various aspects of environmental protection.<sup>3</sup> These groups have prominent representation in the government, which helps to ensure the quality and strict regulation of the technology. In the U.S., opposition to GM technology peaked at times between the 1980s and 1990s but never received the national attention it garnered in Europe.<sup>3</sup>

#### **Discussion and Conclusion**

There is much intricacy surrounding the rhetoric and scientific knowledge regarding genetically modified technology. The transatlantic divide exposes the discrepancy between perception of the technology due to various industrial, cultural, and political assumptions in the U.S. and EU. Theoretically, greater communication and joint policymaking could alleviate these differences.

However, whether either side would compromise their value sets regarding biotechnology is unclear. To progress toward greater unity and receptivity, each governmental body must make available to citizens “common, well-informed scientific advice about the risks of new biotech products and procedures” to make “compatible decisions.”<sup>5</sup> Particular attention must be paid to the general public to ensure greater transparency and communication. Finally, strengthened relations between institutional research bodies in each region should be recognized and accepted to progress in more efficient and adaptable policymaking, derived from mutual understanding.<sup>5</sup> The divide and its implications for biotechnology is at a critical point; if the transatlantic divide is not narrowed soon, it will probably never be alleviated.

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# FLUID TRANSFORMATION: THE SIGNIFICANCE OF WATER IN GREEK MYTH

*By Bailey Woods*

## Introduction

Transformation is something of which we, as humans, are increasingly aware. Throughout history, water has proved to be an archetype—a recurrent symbol or motif in literature, art, or mythology—for transition and transformation in almost every culture. It is one of the only symbols and bodies whose significance has remained over thousands of years; baptisms, sea voyages to “find oneself,” and retreats to rivers for the cleansing serenity of the water are all modes through which we attempt to achieve a transition of some sort. Although in many cultures water has some sort of hand in the transformation of oneself, the Greeks’ myths were often centered on it. It is a symbol for rebirth and renewal, constantly revitalizing characters of classical mythology physically, mentally, and spiritually. Seas and rivers take on an ethereal quality as they epitomize death and rebirth in myth, bringing men to their end and transforming them into new versions of their old selves. Modern ideas of rebirth and transformation can be tied to the interpretations of Greek myth and its representation of water. The motifs of life, death, and rebirth seen throughout the mythological stories of gods, heroes, and men strengthen the insight that we gain from these interpretations. Water expands beyond its traditional life-giving role and is a source of power that generates change in the mind and body throughout mythology. The influence that bodies of water have on mythological characters gives insight into the purpose of the myths and the importance that water holds in religions and mythology across the ages.

**“WATER EXPANDS BEYOND ITS  
TRADITIONAL LIFE-GIVING ROLE AND  
IS A SOURCE OF POWER.”**



**Figure 1.** The nymph, Thetis, dips her son, Achilles, into the river Styx to make him immortal. “Design for Thetis dipping the infant Achilles into the river Styx, 1630-1635” by Peter Paul Rubens is in the Public Domain (PD-old-100). Source: [https://commons.wikimedia.org/wiki/File:Peter\\_Paul\\_Rubens\\_181.jpg](https://commons.wikimedia.org/wiki/File:Peter_Paul_Rubens_181.jpg).

## Analysis

Mythological characters are often physically and mentally captured through their experiences with bodies of water. If we focus on the idea that water acts as a catalyst for rebirth, then we can connect a thread of our understanding of transformation to the interpretations that emphasized water’s otherworldly abilities in Greek myths. From birth to rebirth and reincarnation, water has transcended its traditional life-giving role and transformed the way we think of water in correlation with spirituality.

### *Immortality and Metamorphosis*

One of the chief instances in which a river created a hero is the story of Achilles. His mother, Thetis, upon hearing of Achilles’ prophesied death, took him into the



underworld and “fortified [him] with the stern waters of Styx”<sup>1</sup> by dipping his body into the river (Figure 1). Doing so would “make his fair limbs impenetrable to steel”<sup>1</sup> and save him from destruction. The waters of the Styx make Achilles into the seemingly immortal hero that we meet in Homer’s *The Iliad*. The river coats his skin, transforming his body into something that resembles a god, save for the tendon on his heel by which Thetis dipped Achilles into Styx. His physical transformation made him into as close to an immortal as a mortal can become. Through these events, not only did his body and apparent skill change and grow, but his reputation grew as he gained *kleos*—fame and glory—from his success in battle. The river created a hero, fortifying life in him as he became partially indestructible and immortalizing his name to be celebrated through the ages.

Whereas the water of the River Styx may have fortified Achilles’ body against steel and harm, the water of the “pool of death”<sup>2</sup> transforms Narcissus both mentally and physically in a much more detrimental way. Narcissus falls in love with his reflection within a pool after being tricked by Nemesis for rejecting so many that loved him (Figure 2). The stillness of the water in the pool reflected the mentality of Narcissus as it did to him what he did to others. He fell in love with the vision, and when he got close to it and touched the water, ripples distorted the picture, distressing and paining him as he had done to others when he rejected them. When people got close to him, their vision would be disturbed by his rejection of their touch (namely, Ekho’s). Narcissus pined over his inability to touch his beloved and died over his love for the reflection, just as Ekho died over her love for Narcissus. The pool transformed Narcissus into one of the entranced beings that he always rejected, in turn rejecting him in the end for trying to touch his reflection. The fortification of life and

reflection of one’s personality and deeds in these stories shows water’s ability and power to change how others perceive us in life and death.

### *Born of Water and Sea*

Classical mythology used the sea as a place and symbol of birth. The waves laboriously produced transformations both physically and emotionally, pushing out gods and men into the world, naked and with the influence and strength of the tides that had borne them. Perhaps one of the best-known examples of transformation through the sea in classical mythology is the myth behind Aphrodite’s origins (Figure 3). When Kronos overthrew his father, Ouranos, he cut off the genitalia of the ruling god and threw them into the ocean. According to Hesiod, it was from Ouranos’ genitalia, after a “white foam from god-flesh collected around them,”<sup>3</sup> that a “maiden developed and grew.”<sup>3</sup> The sea, here, literally gives birth to the goddess Aphrodite and transforms her into a physical entity out of the semen from Ouranos’ genitalia and foam. The sea has a mysterious quality about it; it is unknown and uncharted by man, allowing mystical events to take place without further explanation. The water in the story of Aphrodite’s birth personifies the womb; the wild

nature of the sea shapes the goddess’s personality and plays a role in developing the nature of her affinities: pleasure, love, and uncontrolled lust. Aphrodite has no parents, just as the ancient entity *Eros* was parentless and uncontrollable. The sea created a goddess without another god, reflecting the fact that lust, her affinity,

## “WATER PROMOTES TRANSFORMATION OF THE SPIRIT OR MIND.”

has no “parent” or origin. She rose from the mysterious foam of the sea to represent the free, untethered love that does not belong to any one group. Modern practices of transformation such as baptism, cleansing rituals, or even water births (which are growing



**Figure 2.** Narcissus falls in love with his reflection in the water. He is transformed into a Narcissus flower shortly after. “Echo and Narcissus, 1903” by John William Waterhouse is in the Public Domain (PD-old-100). Source: <https://www.google.com/culturalinstitute/beta/asset/cgGohYq-VdecNw>.



**Figure 3.** Aphrodite emerging from the sea after her birth. “Nascita di Venere” by Sandro Botticelli. Public Domain (PD-old-100) through the Uffizi Gallery Collection.



in popularity) can be traced to this interpretation of Aphrodite's origins.

Homer's *Odyssey* also explores the idea that one can be changed or "reborn" through the sea and events that take place on it. Odysseus starts out as a proud leader trying to sail home to glory and fame; he struggles with many conflicts on the water that end up changing him both mentally and physically. His time with Calypso is long and languorous as Odysseus allows the goddess to care for him and keep him safe. Calypso is known as the "concealer," which can be viewed in this metaphor as the pregnancy stage of childbirth. After Odysseus leaves her island, the sea reflects Poseidon's anger at Odysseus over the humiliation of his son, Polyphemus. A storm breaks out, which breaks down Odysseus's state of being, making him weak as he is tossed in the storm, condemning his previously optimistic mentality with the destruction of his ship. The ocean swallows and thrashes the hero, battering him for all his crimes against Poseidon's son, Polyphemus. In this scene Odysseus is transformed into a new version of himself. He survives Poseidon's storm, "all vital force conquered by the sea,"<sup>4</sup> and is reborn through its wrath. Poseidon's storm is Odysseus's laborious attempt to escape the "womb" of the sea that had once concealed him on an island. Odysseus emerges naked from the sea and later mentions "the holy cave of Eileithyia,"<sup>4</sup> (the goddess of childbirth), leading the reader to conclude that Odysseus has undergone some sort of rebirth in his journey (Figure 4). After this pivotal series of scenes, Odysseus's hero identity transforms from pride to humbleness and eagerness to return home not for *kleos*, but for the chance to see his family again. Homer explores this theme of identity transformation through his depiction of the sea and allusions to mythological symbols of birth.

### *Rebirth and Reincarnation*

Rivers in mythology have a powerful, transformative effect on men as well. One of the most powerful of these rivers is the Underworld's Lethe: the River of Forgetfulness (Figure 5). The river is designed to make spirits forget their past lives in preparation for the next, mentally transforming them into new people and essentially continuing the "rebirth" motif present in many sea and river emergence myths. Drinking from the River Lethe, while appearing to prepare the soul for a rebirth of sorts, also marks the end of one's life. This is a prime example of how a body of water can conjure symbols of both new life and death, juxtaposing them to show the circle of life and the connectivity of it all: when one man dies, another is born. In Virgil's *Aeneid*, Aeneas sights the Lethe River where crowds of people swarm its banks, appearing to drink from its waters. He asks his father, Ankhises, what the purpose of this is, and his father answers: "They are the souls who are destined for Reincarnation; and now at Lethe's stream they are drinking the waters that quench man's troubles, the deep draught of oblivion. . . They come in crowds to the river Lethe, so that you see, with memory washed out they may revisit the earth above."<sup>5</sup>



**Figure 4.** Odysseus emerges, naked and transformed, from the ocean. "Odysseus and Nausicaa," by Salvator Rosa, The Hermitage is in the Public Domain (PD-old-100). Source: [https://commons.wikimedia.org/wiki/File:%27Odysseus\\_and\\_Nausicaa%27\\_by\\_Salvator\\_Rosa,\\_The\\_Hermitage.JPG](https://commons.wikimedia.org/wiki/File:%27Odysseus_and_Nausicaa%27_by_Salvator_Rosa,_The_Hermitage.JPG).

This description of the river shows the cycle of life and death as the souls that Ankhises refers to are intended for reincarnation, through which a soul will be reborn and live again in the corporeal world. The Lethe River is the ultimate example of transformation by water because it changes those who drink from it both physically and spiritually. It affects primarily their mentality—or their memory—since when they drink from the river, the souls forget their past lives, erasing any remaining connections and laments. However, if the purpose of drinking from the waters of Lethe is to prepare you for rebirth, then your spirit is transformed as it gets ready to take on and enter the world in a new physical form. Lethe is the epitome of the cycle of life as it transforms those who partake of it and transcends



the limits of death. The rivers of the Underworld—the Lethe along with others—transform the body, mind, and spirit of man, indicating the significance that rivers hold for identity in classical mythology.

### Conclusion

This recurring image of transformation extends past classical mythology and into many other myths. Water is a vessel for change and transition in many cultures. From floods, to the seas and rivers, and even to oaths and baptism, water promotes transformation of the spirit or mind, reincarnating—or giving new life to—the life and culture that the Greeks created. The Greeks firmly believed in the idea of transformation because it gave hope for life after death or for some type of immortalizing effect (Achilles in the River Styx).<sup>1</sup> However, as we have seen in the above examples, water extends past its traditional life-giving role. It is a source of power that generates change in the mind and body throughout mythology. The cycle of life that bodies of water represent in Greek

studying the link between these myths and this prominent archetype, we open the door to understanding humans at a deeper level. We can see the interests and concerns that have transcended time and traveled through the ages, linking civilizations and cultures in their attention to and interpretation of transformation.



**Figure 5.** Souls drinking from the River Lethe for reincarnation. “The Waters of Lethe” by Thomas Benjamin Kennington is in the Public Domain (PD-old-100). Source: <http://mnemosynosis.livejournal.com/23448.html>.

## “TRANSFORMATION THROUGH WATER...HAD AN ETHEREAL EFFECT THAT ACHIEVED THE CONTINUATION OF LIFE, EVEN IN DEATH.”

myth signify the importance that water held to Greeks. Rain gave them crops, the seas were the sites of voyages, rivers acted as a cleansing mechanism for mind and body. The motifs of life, death, and rebirth seen throughout the mythological stories of gods, heroes, and men strengthen the insight that we gain from these interpretations. Transformation through water—especially through seas and rivers—had an ethereal effect that achieved the continuation of life, even in death. By

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# Not Immune TO PITY

This creative short story is based on an experience that drastically changed my life and my perspective of life's inevitabilities. During my health hardship I did not speak about how I felt or how others made me feel. I did not get to voice my concerns, feelings, or thoughts freely with others. Because I was under constant observation, I did not get to break down. My life was going to change, but it seemed like others considered only how their own lives were going to be affected. I became consumed with keeping myself together—pretending to be brave—but the only thing I ever felt from anyone was pity. This piece contains many internalized sentiments about my experience, but I felt compelled to share my story in the hope that others will gain courage from it when faced with a similar situation, as I did during its composition.

During Professor Catalina Bartlett's English 203 class in fall 2015, I received an assignment to write a paper focused on any trivial aspect of the body, specifically describing either adorning it or using the body as a source of animosity. The class was challenged to compare those judgments about our bodies with material we read throughout the semester while incorporating theories about the modern body presented in class. I immediately fell in love with the focus of Professor Bartlett's class and developed a great passion for *Body Studies*, a book by Niall Richardson and Adam Locks that explains body theories brought forth in modern society with reference to past society. *Body Studies* addresses misconceptions regarding the aging body, the freak body, the disabled body, and statuses of the body that either conform or are deviant within a given society.

The format of this work was inspired by *Empathy Exams* by Leslie Jamison; the context and depth of my personal experience is compared with hers throughout my piece. I write in second person for most of the work, even though I am speaking to myself. I guide myself through my own emotion, while constantly reminding myself of how I should be feeling and acting during particular moments of my health. The way I express myself in this piece is very raw. I never admitted these thoughts to anyone before writing this piece—not even to myself.

This work is the product of my coming to peace with my health; it is a result of my coping strategy. To prepare for this paper, I studied body theories from *Body Studies* and researched my particular health condition so I could help the reader envision my situation. The health and medical facts included in this piece give depth to my story and enforce the idea that these things that I share are true and real, and that I am real. To avoid giving too much information away, I was intentionally vague in this sidebar. The formatting of this piece is essential for maximum impact. It must be read with no prior knowledge of what is to come.

## Clinical Details

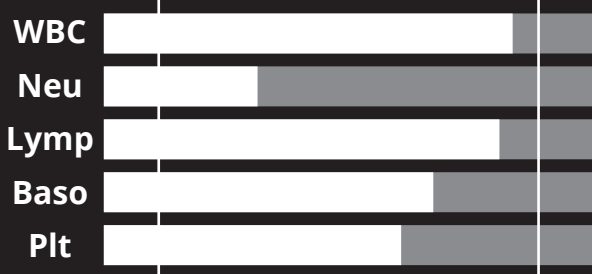
PiD: Karen Galvan

PiD # K347859

Age:17

Sex: Female

Date: 1/15/2013



**CASE SUMMARY:**

You are an 18-year-old female seeking treatment for a severe headache. You have had these before. Truth is, you really just want to get a day off school. You think you hallucinated a bit this morning, but then again, you didn't have any breakfast so maybe that's just it. You are not notably concerned about the headache. This is normal for you. It's just an excuse to dodge the hell out of a very tricky computer science exam.

**MEDICATION HISTORY:**

You are currently only taking allergy medication. It's mid- December and the sniffles linger.

**MEDICAL HISTORY:**

You've never had any broken bones or surgery. You had to quit cross-country in high school because you kept getting fainting spells and the cardiologist said to take some time off. After that 2-month break, running was never the same for you. You don't mention this to the general physician because it was long ago and you're all better now. Your mother gives you the stern stare from across the room and you know it's because you didn't mention it. You wish she had stayed out in the waiting area.

**PATIENT LAB ORDER:**

You are referred to a lab to get standard blood work done once you are feeling better. You believe the doctor when he says it is just the standard thing to do. A couple of days after the doctor's office receives the results you are called for a follow-up consultation and are told to do the blood work again. This is still the standard thing to do. Right?

**RESULTS:**

You are told that there is no fluctuation in your blood count between the two separate blood works. You are told they are dangerously low and it is out of the doctor's specialty to help you any further.

**MEDICATION PRESCRIBED:**

After first consultation:

- Tramadol HCl 500 mg, 1 tablet a day or as necessary. (Treats moderate-to-severe pain.)
- Plenty of sleep and a healthy diet . . . to stop those hallucinations.

After second consultation:

- Folic acid 1 mg, 1 tablet a day. (Helps your body produce and maintain new cells.)

[You are referred to an oncologist.]

**CASE SUMMARY:**

Hematology/oncology: a medical specialty concerning the study, treatment, and prevention of diseases of the blood and the study and treatment of cancer. You are sitting in the waiting area. This is a little scary. OK. It is a lot scary. But, you have to keep it cool. Your mom is next to you and you can hear her nerves under each of her suppressed breaths. You have to keep it together for the both of you.

**MEDICATION HISTORY:**

You aren't taking any medication, although you wish you were. Your stomach is churning from all the nerves. You have the sniffles again but aren't taking anything for it this time.

**MEDICAL HISTORY:**

You are reminded that your cell count is alarming. You can see the astonishment in the doctor's face as he reviews your past labs even though he is trying to not make it obvious. You are then checked for any inflamed lymph nodes and are taught how to check for them yourself when at home. You are asked questions relating to cancer symptoms. Your health has never been an issue before. You have never been referred to any kind of specialist. Well, except for that cardiologist from before, but that's not relevant here. You feel like your body is all of a sudden betraying you. Your body is the enemy now. You feel so lonely like that emotion of conflicted 25-year old Leslie Jamison from "Empathy Exams." All she wanted was for her boyfriend Dave to "discover which emotions were there" as she underwent her pregnancy, correction, unwanted pregnancy.<sup>1</sup> Leslie wanted Dave's support; he failed her. I wanted my body's support; it failed me.

**PATIENT LAB ORDER:**

You are referred to a different blood lab from before to get standard blood work done. Don't expect a change. Your body sucks, remember? Your cells refuse to multiply.

**RESULTS:**

(Refer to above). You are given a lab order to do in a month. He is monitoring you, or better yet, monitoring your blood cells.



### **MEDICATION PRESCRIBED:**

- Calcium (Necessary mineral for maintaining healthy bones.)
- Vitamin B12 (Found in the blood, used to treat gradual harmful anemia. Can boost your energy and immune system.)
- Folic acid

[Third visit with oncologist.]

### **FOLLOW-UP SUMMARY:**

Your blood counts continue to be extremely out of range with no signs of improvements. You have only three more visits before drastic measures are going to be taken, but until then, you will continue to be monitored. You have no idea what those drastic measures are right now. You are about to start your freshman year at Texas A&M University, which means you have to be extra cautious of getting sick since you will have constant and daily exposure to many new people. Your parents want to send you off in a bubble. That is not going to happen. You just want to be normal and have the college experience like everyone else.

### **DIAGNOSIS:**

You have leukopenia. If it sounds complex and scientific then you have yourself one hell of a diagnosis because “Biomedicine [is] concerned with diagnosing and classifying bodies that [are] different from the norm.”<sup>2</sup> Aside from biomedicine trying to ostracize you, all this still isn’t going to stop you from being a relatively normal college student. Leukopenia is defined as low white blood cell count due to low neutrophils or low lymphocytes, which are crucial in your body’s defense against infection.<sup>3</sup> Simply put, your immune system is weak; your body sucks. Your body has betrayed you; your body is the enemy. You will frequently get sick as a result of small exposure to any sort of bacteria or to other people who are also sick. You are advised to be extra careful to not get a fever, but you don’t know why that could be so dire.

### **IT’S MY STORY—I’LL TELL IT MY WAY:**

I have a weak immune system. But I am not weak: not emotionally, physically, or mentally. It seems that no one understands these distinctions. I don’t want all my friends and family to see me differently or treat me any differently; I’m not dying or anything. It’s as if I’m always on display and everyone just watches

# **“I don’t want to be seen as fragile; I am not made of paper.”**

my every move, hovering over me all the time. I might as well be displayed as FREAK SHOW: The Girl in the Bubble. I am a deviant according to the normal health standards, but I am not disabled.

“Disability: the disadvantages or restriction of activity caused by a contemporary social organization which takes little or no account of people who have physical impairments, and thus excludes them from the mainstream of social activities.”<sup>2</sup>

### **BEYOND THE DOCTOR’S OFFICE:**

Having a weak immune system is a limitation for me. I can’t do many things that others can. I have to bundle up extra when it’s wintertime. I have to avoid my friends, my family, and even strangers when they are sick or at least keep a reasonable distance from them. When someone in class coughs, I get sick during that class period. But to have this limitation isn’t that big of a deal to me. I take it as some extra precautions I have to take, but nothing unmanageable. My weak immune system would not be that great of a deal if people didn’t focus on it. Everyone gets sick. If I pass someone on the street and they see that I am sick it doesn’t seem “un-normal.” To them, I am just a normal girl who got a normal cold or flu and am temporarily sick. But to my family, and those who see me every day I am SICK. It is the power of “I am.” It isn’t until people say I am sick that it becomes part of my identity. They say it as if it were a regular part of me, as normal as saying that I am a human. My entire being, my body image, is now described as that cringing word: SICK. I don’t want to be aggrandized for it. As Richardson and Locks mention in *Body Studies*, the aggrandized representation for the freak would emphasize their talents in order to evoke pity. This pity would originate from the astonishment that their “freakishness” didn’t prevent them from being so gifted in their aesthetic or talents. Being sick doesn’t make me any less able for my talents. I’m not any less myself than I was before diagnosed with leukopenia. I’m simply myself. Not a freak. Not disabled. Not in need of pity. I am not the bubble girl.

[Three visits later. About a year since you first began seeing the oncologist.]

## **CASE SUMMARY:**

You are out of time. You have exhausted your visits and now drastic measures are going to be taken. You are going to need to brave a bone marrow biopsy and aspiration. To further explain: bone marrow produces red blood cells, white blood cells, and platelets. In an ideal situation where the bone marrow is healthy, immature blood cells such as stem cells, progenitor cells, and blasts are produced. These cells mature and develop into the red blood cells, white blood cells, and platelets aforementioned.<sup>4,5</sup> By doing this procedure the oncologist will be able to discover the origin of your dilemma. You are to report to the hospital the next morning for the procedure. Your dad went with you to the doctor this time and he forced you to do it that next day. You wanted to wait a week or so, wrap your head around things. He wanted to get this over with; he is a “rip the Band-Aid quick” kind of man. He just wanted to know you were healthy, and the sooner that was confirmed, the better.

## **FAMILY ENCOUNTER DYNAMICS:**

When my family became informed of the procedure, I felt the stereotype of disability all over again. I was the second kind of stereotyped disability mentioned in *Body Studies*. I was the “sweet, young thing whose disability inspired pity and compassion in my spectators [family].”<sup>2</sup> I didn’t want pity from them; I didn’t need them to feel sorry for me. I wanted their empathy. THIS was real now. The possibility of me really having CANCER had now just increased by 10-fold. Everyone who knew about it incessantly asked me what I would do if the bone marrow procedure results came back positive for cancer. I thought to myself, “What was I to do?” Did they expect a specific answer? While I was admittedly worrisome, nothing was officially wrong with me just yet. I wasn’t going to get ahead of myself and start thinking depressive thoughts. It was going to be 2 weeks before I heard from my doctor to get the results. During this hardship I sought empathy. I wasn’t ending a life like Leslie Jamison was ending her fetus’s life. I didn’t seek empathy for my actions or seek empathy as a form of affirmation to justify my actions. Rather, my body wanted to end my own life and it sought no empathy from me. I wanted empathy not only from my friends and family but also from my own body. I also didn’t want everyone to console me with “that must be really hard,” but I also didn’t want everyone to pretend like they knew

what I was going through, because “empathy requires knowing you know nothing.”<sup>1</sup> I just wanted everyone to notice, think, process, and imagine the difficulty I was going through and enter my pain. Empathy can be seen as a kind of “travel” or “penetration” like entering another country.<sup>1</sup> I wanted them to enter my foreign land, in my world where my body had betrayed me.

My brother asked, “How do you feel?”

Internally I thought, Feel about what?

I said, “I’m fine.”

Was I?

“I’m fine,” I repeated.

## **PITY PARTY—FINAL NUMBER:**

Every day I think about how lucky I am to not have cancer. However, every day, I also think about how someone else does. I know that someone else out in the world is seen as a freak or disabled because of it. I don’t feel pity for them because I got to be cancer free and they didn’t; rather, I empathize with them (even though I don’t even know who “them” really is). Cancer kills. Cancer destroys. And I don’t just mean physically. Cancer will tear right through you and your family and friends. Every day, I AM lucky to be cancer free. Cancer free . . . isn’t that such a strong statement? Doesn’t it empower you? Cancer free. Free.

Free . . . am I really free?

I continue to deal with a weak immune system because my “body is identified to be flawed.”<sup>2</sup> I will have to live this way my entire life. I will always run the risk of getting cancer later in life. I guess. Although I am cancer free, I’m not actually free of this sickness . . . and I never will be. I continue to be confined to a cautious way of life dodging every sickly being. I am a slave to my enemy of a body.

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# Do More PROMISCUOUS Honey Bee Queens PRODUCE Healthier Hives?

*By Alexandria Payne*

## **Introduction**

The health of honeybee populations has become a hot topic in recent years because of the decline of hives resulting from parasites, pesticide use, malnutrition, and other factors.<sup>1</sup> Honeybees contribute about \$17 billion annually to the United States' economy through their pollination services and are responsible for 35% of the world's overall food production.<sup>2,3</sup> A healthy and productive honeybee queen has much to do with a hive's overall health—the queen is the sole individual responsible for laying the eggs that replenish the worker bee population. A virgin queen will undertake a single mating flight in her life, during which she mates with an average of 12 male bees. The semen collected during this mating flight will have to last the rest of her life.<sup>4</sup> Once a queen depletes her store of sperm, she must be replaced by a new virgin queen or the hive will eventually collapse. The reproductive

potential of queens and the quality of such characteristics as physiology and pheromone production depend on how much sperm a queen collects on mating flights.<sup>6,7</sup> I wanted to know whether the volume of semen a queen is inseminated with affects the overall health and growth of a colony. Hives containing queens artificially inseminated with a low volume of semen were compared with hives with queens artificially inseminated with a high volume of semen. The growth of each hive was measured on the basis of several factors, including the total amount of honeycomb built, the amount of sealed worker and drone brood (the number of female and male eggs, respectively, laid by the queen), and the amount of food storage within the hive.

## **Background**

The fertilized eggs that a queen lays hatch into female worker bees that are responsible for all the tasks involved

in hive maintenance, including raising young, foraging for food, and defending the hive from predators. When a queen depletes her store of semen, she cannot produce fertilized eggs and instead lays unfertilized eggs that develop into the male bees whose only function in life is to reproduce.<sup>5</sup> Worker bees can sense when their queen is low on sperm and will raise new virgin queens by feeding selected eggs a special diet called royal jelly. As soon as a new virgin queen emerges, the worker bees will typically kill the old queen. Before this study, how the insemination volume of a queen affected a colony's growth was unknown. Honeybee queens typically live longer if they have a high reproductive potential due to a large volume of stored semen.<sup>6</sup>

## **Methods**

This experiment took place at the Honey Bee Research Facility located at the Riverside campus of Texas

**"Once a queen depletes her store of sperm, she must be replaced by a new virgin queen or the hive will eventually collapse."**



A&M University. To minimize the effects of genetic variation, all the experimental queens used in this study came from a single colony. The honeybee queens were separated into two nearly equal experimental groups that consisted of high-quality (high insemination volume) queens and low-quality (low insemination volume) queens. Nine of the experimental hives consisted of high-quality queens artificially inseminated with 9  $\mu\text{L}$  of semen (an above-average semen volume for naturally inseminated queens). The other 10 experimental hives in the study consisted of low-quality queens artificially inseminated with about 1.5  $\mu\text{L}$  of semen (a low semen volume for naturally inseminated queens).

The growth of each colony was measured and recorded on a biweekly schedule from May to October 2015. A gridded wooden frame of 1  $\times$  1 in. squares was used (Figure 1). This gridded frame made it possible to measure the parameters of colony growth, including total amount of honeycomb built, the amount of female and male sealed brood laid by the queen, and the amount of food storage within the hive. A hive was no longer considered part of the study if the experimental queen was killed and replaced by a new queen or if the hive collapsed for any reason.

## Results

Contrary to expectations, no overall statistically significant differences were evident in any measure of colony growth between hives led by low-volume versus high-volume queens. The graphs in Figure 2 depict the different parameters of colony growth between the two experimental groups. In general, the two experimental groups follow a similar pattern across the different measures of colony growth. Figure 2C does show some variation between the two queen types because, unlike

the other parameters measured, male progeny are not produced as often or not produced at all in some hives. The resulting small sample size is the cause for the disparity between samples. A sampling bout occurred every 2 weeks during the sampling period and involved collecting representative data pertaining to the parameters of colony growth.

## Conclusion

From the results of this experiment, we could not conclude that the insemination volume of a honeybee queen affects a colony's growth. We could project that, with all other variables constant, a hive containing a queen with a low insemination volume will produce just as much honeycomb, offspring, and food storage as a hive containing a queen with a high insemination volume. This could be helpful information for both commercial and recreational beekeepers because they now can better narrow down what factors influence a queen's reproductive health and put more focus and research on other potential issues that may be affecting a colony's growth. To thoroughly investigate this question, another season's worth of data collection would be ideal to generate a more definitive answer as to whether

the insemination volume of queens affects colony growth. Having a larger sample size after another season's worth of data collection would also help by decreasing variance and making the resulting conclusion more statistically reliable.

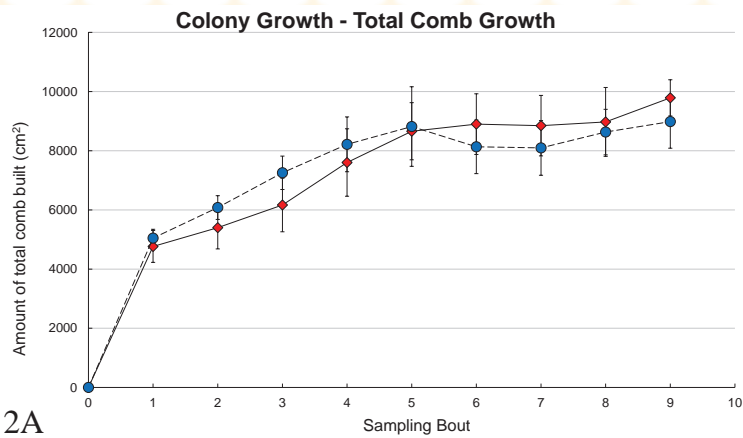
## Acknowledgments

I thank Dr. Juliana Rangel for serving as my adviser and giving me the opportunity to conduct research in her lab. I also thank Susan Cobey for her assistance in the artificial insemination of the queens used in this experiment and Dr. Jane Packard as well for her help in the statistical analysis of these data. I recognize and thank the members of the Rangel lab, including Lauren Ward, Elizabeth Walsh, and Pierre Lau, who assisted me with data collection.

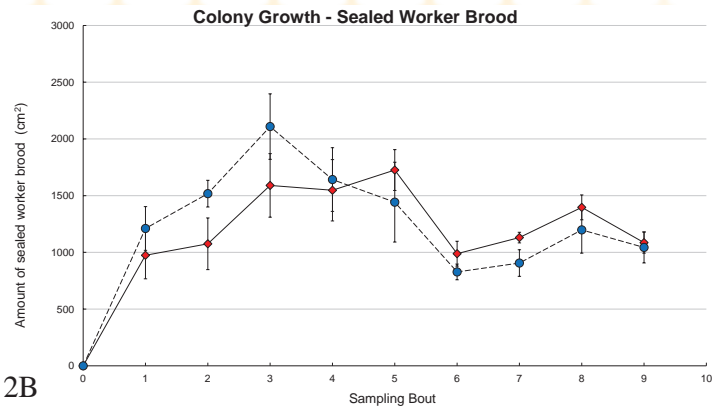


**Figure 1.** Gridded wooden frame used to measure colony growth.

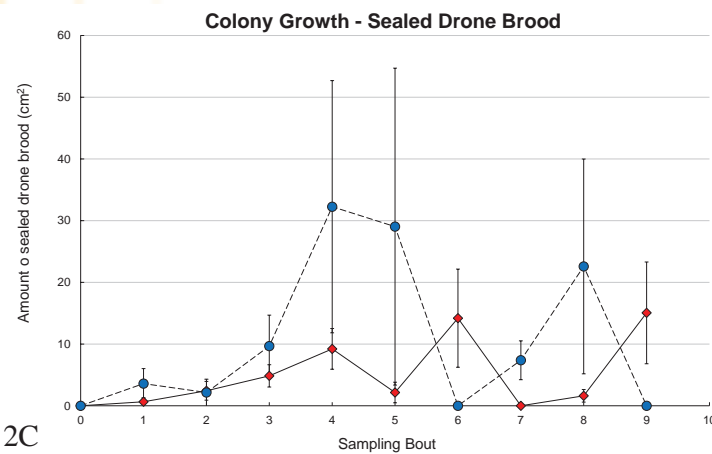




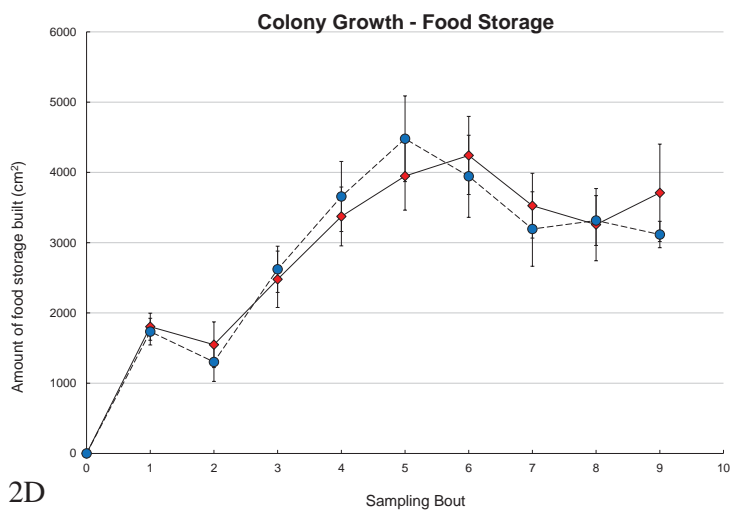
2A



2B



2C



2D

**Figure 2.** Honeybee colony growth. The blue data points represent the hives containing queens with high insemination volumes, whereas the red data points represent the hives containing queens with low insemination volumes. (A) Total amount of comb growth. (B) Amount of sealed female worker brood laid within the hives. (C) Amount of male sealed brood laid within the hives. (D) Food stored within the hives.

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# THE MAKING OF AN EXHIBITION: BRINGING THE EIGHT TO CAMPUS

By Mary Garrido



**Figure 1.** Members of The Eight and friends at John French Sloan's Philadelphia Studio, 1898. Image is in the Public Domain (PD-1923). Source: [https://commons.wikimedia.org/wiki/File:John\\_French\\_Sloan\\_Studio.jpg](https://commons.wikimedia.org/wiki/File:John_French_Sloan_Studio.jpg).

Art exhibitions are prevalent throughout campus, but few people understand the work that goes into making an exhibition a reality. It is a challenging but rewarding process. In the many months leading up to my senior year, I served as assistant curator for an art exhibition of eight prominent American Realists. The show was aptly named *Americanisms* and was held in the Forsyth Galleries of the Memorial Student Center. My duties included assisting Dr. Stephen Caffey in preparing research on each artist in addition to curatorial and catalog planning. "We were able to bring together a group of works that had never been exhibited anywhere," Caffey said, "making this a groundbreaking show for the Forsyth as well as a groundbreaking show in the history of exhibitions." For the first time in history, guests were allowed to view these paintings by all eight artists in one room. Such an accomplishment is an artistic stride not only for Texas A&M but also for the milieu of art history.

"The Eight," as they were called, came to be known not by a particular artistic style, but by a

shared interest in changing the way art was exhibited at that time. The story of The Eight demands to be told because it recounts the birth of the modern American artistic style. These artists acted not only as colleagues but also as a support system to one another, with unique approaches to capturing the urban street scene. Similarly, the exhibition would not have been possible without the generosity and guidance of professors such as Dr. Caffey, whose undying passion for the arts inspires me more than he could ever know, and for the whole staff of the Forsyth Galleries—Amanda Dyer, Heather Bennett, and everybody who made this exhibition possible. The show is truly the highlight of my collegiate career and is something I will hold close to my heart for a long time.

Akin to the artists featured, the creators of our Texas A&M exhibition faced arduous challenges in making this exhibition—which almost did not happen—a reality. "The first thing that comes to mind," Dr. Caffey said: "since neither the Forsyth Galleries nor Texas A&M are known quantities in the art world, it was initially difficult

to convince major museums and galleries to lend works worth hundreds of thousands of dollars (or more) for the *Americanisms* exhibition." Heather Bennett, collections manager at the Forsyth Galleries, supports that claim by recalling that "it was very challenging due to the location of objects peppered all over the country. There were objects in Nebraska, Connecticut, and DC, to name a few. After talking to a lot of art shippers and acquiring several quotes, it was becoming obvious that this was a complicated task. There were also a lot of restrictions and expectations attached to several of the loans as well."

It is a testament to the dedication of the Forsyth Galleries' staff that despite these many roadblocks they made the *Americanisms* exhibition a great success. "One of the goals of this exhibition was to build relationships with other museums so that they can see we're reliable, we're trustworthy, we are going to treat their objects well; we are going to thank them loudly and proudly," said Dyer, assistant director to the University Art Galleries Department. It goes to show that Texas A&M is ready to handle

large-scale exhibitions in the future with a professional staff that possess immense passions for art. "It was wonderful to see other pieces juxtaposed with our works," said Bennett, "it was wonderful the way the pieces chosen complimented the pieces in our collection. Dr. Caffey did a great job of selecting certain works. Once everything was here and hung on the walls, I felt very accomplished. Over a year of my hard work had come to fruition and I felt a sort of calm."

With this groundbreaking exhibition, Texas A&M has made a name for itself in the art world, backed by a staff prepared to handle these pieces with the respect they deserve, and with students ready to be inspired by them. One hundred years after their creation, these paintings have surely put Texas A&M on the art map and opened the doors for greater things to come for the campus art galleries. As an Aggie, I believe that it is my duty to not only tell the story of bringing The Eight to campus but also to go beyond the paintings and recount the legacy these artists left behind—the making of an exhibition.

■ ■ ■





**Figure 2.** Robert Henri, *Gertrude Vanderbilt Whitney*, 1916.

Images are in the Public Domain (PD-1923). Sources: [https://commons.wikimedia.org/wiki/File:Gertrude\\_Vanderbilt\\_Whitney,\\_Henri.jpg](https://commons.wikimedia.org/wiki/File:Gertrude_Vanderbilt_Whitney,_Henri.jpg) and [https://en.wikipedia.org/wiki/Robert\\_Henri#/media/File:Robert\\_Henri\\_1897.jpg](https://en.wikipedia.org/wiki/Robert_Henri#/media/File:Robert_Henri_1897.jpg).

The role of assistant curator is similar to the role of a detective in many ways. A competent sleuth must encompass all aspects of a case, or in this instance, an exhibition. When I began to conduct my research I was not familiar with the backstories of each artist, but I was aware of the renowned Armory Show—and with that I had uncovered my first clue. As I went deeper into the subject, I became totally enthralled with the challenge of investigating these clues to form the bigger picture of this exhibition. By scouring academic journals and trekking the floors of Evans Library, I began my hunt to discover all that I could about these eight artists.

The artists featured in this exhibition came to be known as “The Eight” not by their own choosing, but by the press after

their first exhibition in 1908. The title alluded to the fact that the artists’ cause had little to do with stylistic similarities and everything to do with the politics of art at that time.<sup>1</sup> “The Eight”—Arthur B. Davies, Ernest Lawson, Everett Shinn, George Luks, John Sloan, Maurice Prendergast, and William Glackens, headed by Robert Henri—was formed with the intention of challenging the way art was taught and exhibited in the United States. They consequently succumbed to the press and referred to themselves as “The Eight,” first gaining widespread attention when they put on a show at the Macbeth Gallery in New York City. The Macbeth exhibition proved to be an unprecedented achievement of modern art. With their new style, they won the approval of heiress and art patron Gertrude Vanderbilt Whitney, a progressive woman who challenged the traditional domestic roles of her day.

Here she is seen in a 1916 painting by Robert Henri (Figure 2). Her husband did not allow her to hang it in their Fifth Avenue townhouse because she is seen wearing pants, something women rarely did at the time, so the painting hung in her private studio. That same studio later became home to the prestigious Whitney Museum.

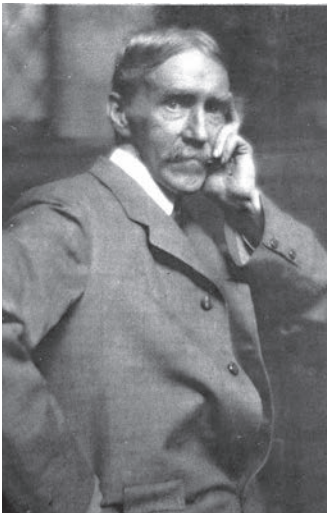
In 1911, Gertrude sponsored a major exhibit of modern American art in New York’s Madison Gallery. The show would eventually lead to the formation of the Association of American Painters and Sculptors. The aforementioned



**Figure 3.** William Glackens, *Wickford Beach*, 1909.

Images are in the Public Domain (PD-1923). Sources: [https://commons.wikimedia.org/wiki/File:William\\_Glackens\\_AAA\\_munswlp\\_8770.jpg](https://commons.wikimedia.org/wiki/File:William_Glackens_AAA_munswlp_8770.jpg) and [https://commons.wikimedia.org/wiki/File:William\\_Glackens\\_-\\_East\\_River\\_Park\\_-\\_Google\\_Art\\_Project.jpg](https://commons.wikimedia.org/wiki/File:William_Glackens_-_East_River_Park_-_Google_Art_Project.jpg).





**Figure 4.** Maurice Prendergast, *In Luxembourg Gardens*, c. 1907.

Images are in the Public Domain (PD-1923). Sources: [https://commons.wikimedia.org/wiki/File%3AMaurice\\_Brazil\\_Prendergast.jpg](https://commons.wikimedia.org/wiki/File%3AMaurice_Brazil_Prendergast.jpg) and [https://commons.wikimedia.org/wiki/File:Maurice\\_Prendergast\\_-\\_In\\_Luxembourg\\_Gardens\\_-\\_Google\\_Art\\_Project.jpg](https://commons.wikimedia.org/wiki/File:Maurice_Prendergast_-_In_Luxembourg_Gardens_-_Google_Art_Project.jpg).

Arthur B. Davies later became president of the association, and in the summer of 1912, he was inspired by a catalog from a large show of modern art being held in Germany. He soon began contacting artists and galleries to produce an exhibition of modern art in New York similar to the one in Germany. The resulting show opened February 17, 1913. It was officially called the *International Exhibition of Modern Art* but became known as the Armory Show. Four thousand guests attended the opening gala and the show served as a catalyst for increasingly independent American artists.

When they were conceived, the paintings featured in the *Americanisms* exhibition were very avant-garde for most American audiences. The art world simply had different standards from those of today. Women were not expected to sit through a study of the male figure. By contrast, as a visualization student in today's times, I must complete a life drawing class to receive my degree. Thomas Eakins, a teacher who inspired many of The Eight, was in fact persecuted for exposing his female students to a male model during a class. He was asked to resign and was forced to seek work elsewhere. Nowadays, Eakins is regarded as one of the most important American artists of any period, but it was clearly not without its costs. The way these standards of teaching have evolved since that time is almost mind-boggling to me, and my hope is that these standards continue to evolve.

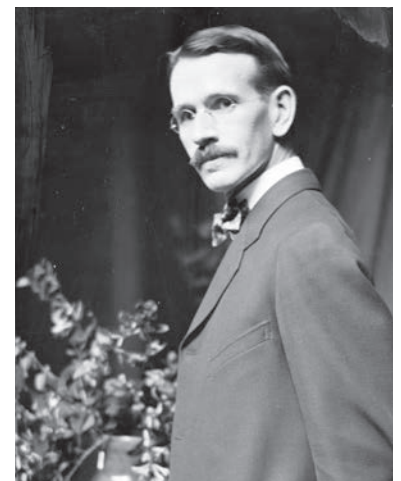
Strongly influenced by Renoir, Glackens is considered one of the realists of the group, depicting life as he saw it. He used vibrant hues in his depictions of daily life, capturing these delicate moments in time (Figure 3). If it were not for artists like him, we would never have the chance to be imprinted by these moments. There is a saying: Man dies twice—once when he takes his last breath and again when his name is said for the last time. I challenge that claim to say that man has a third chance at life—when the things of his world have passed, what will remain is the impressions he made on others, the emotions he evoked during his time spent on Earth. Whether it be through art that captures an unspoken emotion or an act of compassion, he will have a ripple effect that will live through

the generations. It may be hard to visualize or put into numbers on a graph, but the effect of emotion art presents and how it affects people's daily lives will echo into eternity. And with that, I find peace in knowing that somehow in some way our souls may never die, and we may live on forever through art.

Stylistic diversity existed within this group, and Prendergast is the perfect example of the artistic diversity as seen by this postimpressionistic piece (Figure 4). It is easy to see how Prendergast's style differs from the realness of Henri's portraits, for example. Like Lawson and Davies, Prendergast was inspired by nature and portrayed it with his experimental brushwork. "My favorite part was opening the

crates and seeing the works in person because we have been corresponding with these people for months and looking at a little thumbnail, and I knew what the pieces looked like, but to be able to really see them in person and see how the light played on and the brushstrokes and the colors—it was really cool" Dyer said. No feeling in the world is like standing in front of a painting to fully experience it, the way it was meant to be seen—not on a computer or even in some article in a journal, but to see it yourself face-to-face in your own campus galleries not a block or two from your dorm.

Last summer, my family and I went to Italy for our first family vacation in more than 20 years. I will forever be grateful for this once-in-a-lifetime experience. There, the saturation of masterpieces overwhelms the senses. I distinctly remember the sounds of crowds, the smell of smoke, even the taste of rose-flavored gelato on my lips; it is not something that can be replicated in any other form. Similarly, seeing the works of Michelangelo in St. Peter's Basilica reminds you how small you are compared with the timeless and irreplaceable artifacts in front of you. Truly, nothing compares to the chance to see the brushstrokes and colors of paint piled on like the layers of a jawbreaker onto the canvas, in the original lighting they would have been seen in, to travel back in time and imagine the musk of senators of the ancient republic in their robes, crowded around to take a look at the newly



**Figure 5.** Arthur B. Davies. Image in the Public Domain (PD-1923). Source: [https://commons.wikimedia.org/wiki/File:Arthur\\_B.\\_Davies.jpg](https://commons.wikimedia.org/wiki/File:Arthur_B._Davies.jpg).





**Figure 6.** Ernest Lawson, *Ice in the River*, c. 1907. Image is in the Public Domain (PD-1923). Source: [https://commons.wikimedia.org/wiki/File:Ernest\\_Lawson\\_-\\_Ice\\_in\\_the\\_River\\_-\\_Google\\_Art\\_Project.jpg](https://commons.wikimedia.org/wiki/File:Ernest_Lawson_-_Ice_in_the_River_-_Google_Art_Project.jpg).

commissioned Bernini; to see how the light plays off it in a room it was meant to be illuminated that way, the thick layer of smoke and incense residue from centuries of candles burned for the sake of devotion and blessed sacrament, to stand were the caesars have stood admiring the same paintings. To make the realization that these places exist in a place outside of your imagination is a surreal experience to say the least. No matter of words can do it justice; it is indescribable unless you are there to see it for yourself.

In keeping with the progressivist theme, Arthur Davies approached his paintings with more symbolism and less true-to-life realism than other members of The Eight. He



**Figure 7.** John Sloan. Image is in the Public Domain (PD-1923). Source: [https://commons.wikimedia.org/wiki/File:John\\_French\\_Sloan.jpg](https://commons.wikimedia.org/wiki/File:John_French_Sloan.jpg).

approached his depiction of landscapes and scenery with a dreaminess that is not as blatant as that found in the other paintings. His renderings were shaped to fit the ideals he was wanting to portray and the emotions he wished to express. Though different stylistically, he kept with the creed of the group to challenge the way nature was being depicted at the time. Here spring manifests as an apparition of light and etherealness (Figure 5). Perhaps motivated by

a sentimentality for the seasons, Davies understood that the seasons of life are always changing and nothing is permanent, as much as we would like it to be. Fall semester becomes spring semester and soon it will be summer break again. Soon the class of 2050 will be upon us, and we will be asking ourselves, “What do these kids know about Old Army?!” It is important to take the time to capture and appreciate our seasons while they last and to understand that though one season may pass, another will always be on the horizon.

Here you can see the way Lawson depicts the industrialization of Manhattan in comparison with its natural, untouched state (Figure 6). Color was used for emphasis and vibrancy in his work, which focused mainly on the outskirts of cities. That approach was progressive for the time, as well in the way he captured these humble and subdued scenes of nature. I am a Catholic school survivor, and anybody who has attended Catholic school knows what I’m talking about. Let me tell you that when you wear the same uniform every day for 12 years, you will try anything you can to stand out. This made the changes these artists were making in

the art world all the more relatable to me. Maybe they didn’t try to stand out with flashy accessories or dramatic hairstyles, but they decided to challenge the standards of acceptable art at any cost and it paid off for them in the end.

One of my favorite paintings from the exhibition is John Sloan’s *The White Way* (Figure 7). Looking at it, you have to consider what it was like at that time—the year was 1926. Al Capone ruled Chicago and prohibition was in full effect. The Wall Street crash was just over the horizon, and just a few years earlier the women pictured were granted the suffrage for which they vociferously fought. With their bobbed hair and short skirts, more and more of these girls were beginning to step out of the traditional roles and enter the workforce. The “flapper” style we see in this painting epitomized the high spirits and carefree attitudes of America’s youth. It was a time of material prosperity and unparalleled social change. Thanks to John Sloan, we have this fleeting moment of a defining chapter in American history captured forever. As students, our time spent at Texas A&M is similarly fleeting.

When I was a freshman, my mom told me to make time and appreciate college because it goes by faster than you think and that one day I would wake up and I would be graduating. With this being my last year at Texas A&M, I started making it a point to not spend my days in so much of a rush. Some days I might choose to take the long way to class, to marvel at the campus landmarks I have come to know as an attempt to recapture the fleeting moments of my time spent here. Comparably, it has been said that the true theatre of New York is the streets. It was those lively scenes that caught the attention of The Eight. These artists did not paint the working class as struggling or hopeless, but as people full of life—from scenes of bars, intimate exchanges in Chinese restaurants, and vaudeville shows, to a little boy reveling in what might have been his first pair of shoes (Figure 8). These artists captured



**Figure 8.** George Luks. Image in the Public Domain. Source: [https://en.wikipedia.org/wiki/File:George\\_Luks\\_1.jpg](https://en.wikipedia.org/wiki/File:George_Luks_1.jpg).

the authenticity of the public with a no-holds-barred attitude. It may not be obvious, but with social media platforms such as Instagram and Snapchat, many of us take the same approach to capturing the world we see around us.

I firmly believe these artists would have no trouble in ascertaining beauty anywhere, even on the streets of Northgate. It is amusing to entertain the thought of Everett Shinn sitting in

a booth at The Chicken or at Harry's with his favorite drink attempting to capture what he sees; peering through the thick, musty darkness broken only by the lasers choreographed to the sound of blasting country music . . . witnessing dancers with beer in hand cross the time-worn wooden planks of the floor in search of their next dance partner for the night. Perhaps one of the artists would have carved his name into the table as if to say, "I was here" in the hopes of being remembered by the future classes to walk these halls.

One of my favorite lines from one of my favorite characters of any television show, the fictional Don Draper, once said, "Nostalgia—it's delicate but potent." In Greek, 'nostalgia' literally means, "the pain from an old wound." It's a twinge in your heart, far more powerful than memory alone. It takes us to a place where we ache to go again, to a place where we know we are loved."<sup>2</sup> Isn't that what that this exhibition is all about? To give us the opportunity to travel back in time, if but for a moment, to be nostalgic and reminisce about a life we never lived. To remember a face we have never seen before, to be present in a time that exists only in our imagination. To be involved in conversations we never heard, to wander a park we never visited, to fall in love with a woman we have never met.

These men sought to capture a turbulent era in American history. These artists were thrust into a lifetime that spanned the assassination of Abraham Lincoln to the rise and fall of the Roaring Twenties. By chance or maybe fate, the legacy of these artists is that they came to form a group that would mark a watershed moment in the artistic culture of America. These artists were once students like us. Like them, we all possess the potential within ourselves to challenge the way things are taught or understood as truth in our world—if we are brave enough to do so. In a way, this is an exhibition about all of

us. Every time we post a picture of ourselves with friends or a beautiful view of our campus, or stand up for something we truly believe in, we become artists in our own right by finding beauty in everyday life.

As college seniors, many of us can use this same approach to life—the approach that reminds us that every moment spent here is ephemeral and worth capturing. One hundred years later we are still looking at the paintings of *The Eight* in awe. They have stood the test of time. If you could, what moments would you think to capture? Would it be a defining lecture by your favorite professor? A night out with friends at a favorite place? Receiving your Corps Brass? The sacredness of Muster? Looking back, there truly is a spirit that can ne'er be told at Texas A&M—a nostalgic era we will one day seek to recapture.

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# THE GOOD AND THE BAD UGLY

## HOW LITERATURE CAN INFLUENCE CONSERVATION EFFORTS

*By Lauren Naylor*

### Introduction

Fantasy literature uses animal characters to convey ideas, and influential authors such as J.R.R. Tolkien use creatures to both evoke disgust and engender affection from the reader. As an important figure in fantasy literature, Tolkien holds tremendous influence over the style and characterization tactics that other authors in the genre use. In some situations, his characterization of animals encourages a positive image that helps to galvanize support for their conservation. In other situations, however, he contributes to existing negative stereotypes. Tolkien's use of anthropomorphism shows how our perception of animals can be influenced by their presentation in literature and therefore helps shape our opinions of conservation needs for the anthropomorphized species.

### Analysis

#### *The Good*

In *The Hobbit*, the character Beorn is introduced as a skin-changer, or one who can change forms. The character Gandalf describes Beorn as follows: "Sometimes he is a huge black bear, sometimes a great strong black-haired man with huge arms and a great beard." Gandalf is careful

in his explanation of Beorn's character, saying, "He can be appalling when he is angry, though he is kind enough if humored."<sup>1</sup> That warning fits well with the modern reputation of the bear. Gandalf articulates the fine line between reputation and actuality by respecting Beorn's potential to be a dangerous enemy while still expressing hope that he would make a good friend. That approach leaves the reader with an overall positive opinion of these bear-like characters yet still acknowledges the danger associated with the animal.

Ecologically, bears are among the most dangerous predators in Europe and North America. However, with a lovable and cuddly image perpetuated by tales such as *Winnie-the-Pooh* and *The Jungle Book*, the intrinsic danger of the bear is often overlooked. As many as 100 people are injured by bears yearly in national parks, yet despite these many incidents involving serious injuries and even death, the image of bears being cute and friendly remains impressed on the public mind.<sup>2</sup>



Although black bears are listed as Least Concern by the International Union for the Conservation of Nature (IUCN), they are a species well positioned to garner support for conservation efforts.<sup>3</sup> Tolkien's depiction of bears would probably positively influence conservation campaigns for the black bear. In *The Hobbit*, Tolkien manages to

anthropomorphize the bear in a way that is holistically favorable and reflective of its natural ecology. Although he respects their ability to be dangerous, he solidifies Beorn's positive reputation by making him a war hero in the Battle of Five Armies when he removes a mortally wounded Thorin Oakenshield from the fray.<sup>1</sup> Through that action, Tolkien aligns bears with the good side and adds his fantasies to the ranks of *Winnie-the-Pooh* and *The Jungle Book* that exalt bears as being of good character in stories and worth protecting in reality.

### *The Bad*

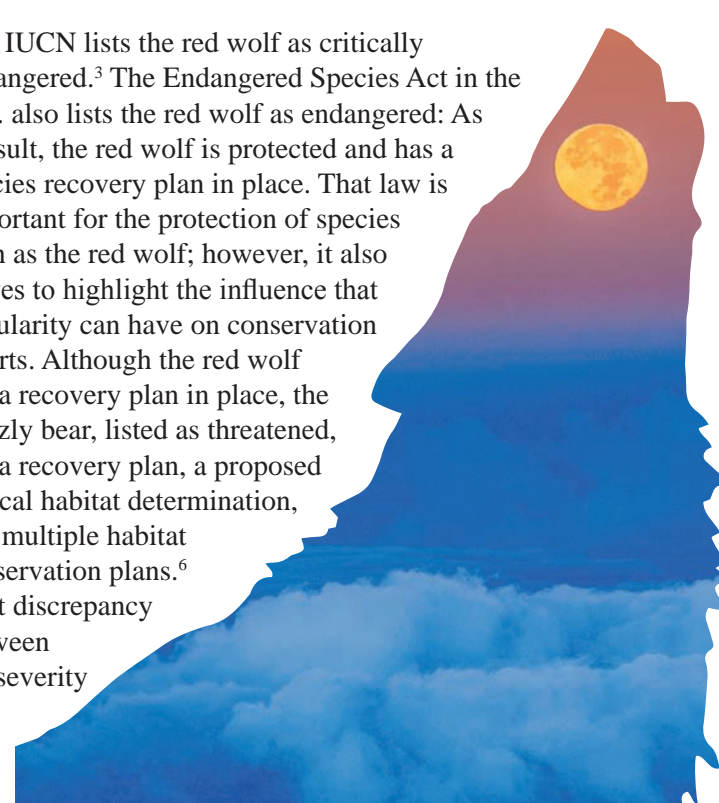
Within Tolkien's fantasies exists an evil breed of wolves known as the Wargs. Tolkien is clear with his anthropomorphism of these wolflike creatures that they are entirely evil. He gives them a language but describes it as sounding "dreadful" and concerning only "cruel and wicked things."<sup>1</sup> In *The Hobbit*, Tolkien depicts Wargs as merciless killers and man-eaters; their plot with the goblins involves mass killings of men, women, and children.<sup>1</sup> That behavior is displayed again in *The Fellowship of the Ring*, when the fellowship is attacked by Wargs on their way to Moria.<sup>4</sup> The Wargs can harbor malicious motives not fueled by hunger alone.

With regard to the ecology of wolves, Tolkien incorporates elements of their natural behavior but depicts them in a negative fashion. For example, in Tolkien's description of the Warg pack, he exaggerates the natural pack size and ignores most of their social dynamics. In *The Hobbit*, Bilbo Baggins comments on the extensive size of the approaching Warg pack, saying, "All of a sudden there were hundreds of eyes looking at them."<sup>1</sup> In nature, large wolf packs consist of only 10–15 animals, with most being much smaller. These packs are made up of a breeding pair and one or two litters of their pups, creating a tightly knit and cooperative family group.<sup>2</sup> By neglecting to include that family dynamic and increasing the pack size, Tolkien

gives the reader a superficial understanding of the pack as simply being large and scary. The only real detail on the social dynamic of the pack is that they have a leader. Scientific studies support that point: packs are shown to maintain a strict hierarchy and have established leaders.<sup>2</sup> The leader of the Wargs, however, is depicted as more of a military commander, "summoning his pack to the assault."<sup>1</sup> Although pack leaders decide when to hunt, they also make decisions that more directly affect the pack's health and well-being.<sup>2</sup> Tolkien's work largely ignores that role, making the role of the pack leader one-dimensional and hostile. That adverse use of anthropomorphism emphasizes the negative stereotype associated with wolves.

As predators, wolves fill an important ecological niche. Their role encourages "increased species interactions, improved nutrient cycling, limited mesopredator populations, and [provides] food web support for scavengers."<sup>2</sup> Stories such as Walt Disney's *The Three Little Pigs* and Serge Prokofiev's *Peter and the Wolf* paint the wolf as a villainous creature intent on killing and destroying the protagonists. That trend extends as far back as Aesop's fables, the most famous being "The Wolf in Sheep's Clothing," which has permeated modern culture to the point of becoming a proverbial warning.<sup>2</sup> This phenomena of an unsupported reputation is present across the globe, where the wolf has remained an "archetype of evil" despite the conclusions of modern authorities that most, if not all, alleged wolf attacks have been false claims.<sup>2</sup> The myth of the man-eating wolf seems unfounded and probably was established in earlier centuries by the rabid behavior of infected wolves and dogs.<sup>2</sup> Centuries of folklore have perpetuated that reputation, and as seen through Tolkien's Wargs, it is still present in modern works of literature.

The IUCN lists the red wolf as critically endangered.<sup>3</sup> The Endangered Species Act in the U.S. also lists the red wolf as endangered: As a result, the red wolf is protected and has a species recovery plan in place. That law is important for the protection of species such as the red wolf; however, it also serves to highlight the influence that popularity can have on conservation efforts. Although the red wolf has a recovery plan in place, the grizzly bear, listed as threatened, has a recovery plan, a proposed critical habitat determination, and multiple habitat conservation plans.<sup>6</sup> That discrepancy between the severity



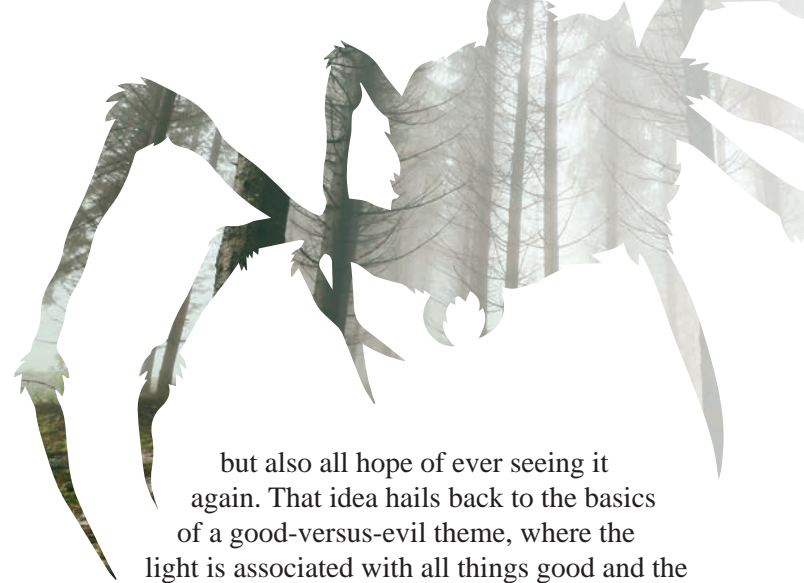


of conservation need and the level of conservation action shows how public willingness to protect certain species can influence policy. Ecologically, both the bear and wolf play an important role in their environments. In literature, however, one is often depicted as being cute and cuddly and the other a cunning killer. Tolkien's treatment of wolves helps to maintain their negative image in the public eye and probably does nothing to help modernize their reputation or strengthen wolf conservation efforts.

### *The Ugly*

Although wolves may be painted in a negative light, no creature has Tolkien connected more clearly or frequently to darkness and disgust than the spider. Tolkien's description could be attributed to the cultural superstitions that surrounded him, since spiders amassed a bad reputation in Europe early on. Tolkien consistently describes his spider characters as being hateful and self-seeking creatures, intent solely on the destruction of others. Malevolent spiders make their first appearance in *The Silmarillion* per the loathsome character Ungoliant. Ungoliant was a great she-spider, thought to be one of the first creatures corrupted by the fallen character Melkor, but who had "disowned her Master, desiring to be the Mistress of her own lust."<sup>7</sup> *The Two Towers* reiterates that independently evil nature of the spider, when the spider Shelob is described as having a mutualistic but unattached relationship with the dark lord Sauron. Like Ungoliant, Tolkien describes Shelob only as being interested in satiating her personal gluttony, as a monster who "only desired death for all others, mind and body, and for herself a glut of life."<sup>4</sup> That independence and self-serving interest help to solidify the spider's role as a disgustingly evil monster.

Tolkien's most effective method of distinguishing the spider as revolting and evil is the association he creates between spiders and darkness. For example, in *The Silmarillion* Tolkien gives Ungoliant the power to create darkness. "A cloak of darkness she wove about them . . . an Unlight, in which things seemed to be no more, and which eyes could not pierce, for it was void."<sup>7</sup> Fear of the dark is a common phobia, and by connecting this inherent fear with spiders Tolkien creates an instinctual connection between his spider characters and fear itself. Tolkien not only anthropomorphizes spiders as bringers of darkness but also, in a sense, anthropomorphizes darkness itself. For Tolkien, darkness was more than the absence of light; it was a multifaceted state of being. The description of Shelob's lair in *The Two Towers* further emphasizes that portrayal: "They walked as it were in a black vapour wrought of veritable darkness itself that, as it was breathed brought blindness not only to the eye but to the mind, so that even the memory of colours and of forms and of any light faded out of thought."<sup>8</sup> The darkness that Tolkien associates with spiders is one of power, capable of removing not only light



but also all hope of ever seeing it again. That idea hails back to the basics of a good-versus-evil theme, where the light is associated with all things good and the darkness indicates the bad.

The fear of spiders is pervasive in Western culture. That fear might be related to an intrinsic disgust response that associates the spider with disease and infection. The association has historical roots; during the Great Plagues in Europe spiders were viewed as "harbingers of the plague and death."<sup>9</sup> Those associations may have stemmed from harmless spider bites that caused a painful systematic reaction and were then assumed to be the cause of unrelated diseases prevalent during that period. The associations also may have resulted from the tendency of spiders to be found in similar areas to the disease-carrying black rat.

Spiders play a vital ecological role that often gets overlooked in light of their less than favorable reputation. Although some spiders create fantastic webs and others reduce populations of pest insects, the only aspect of their ecology that typically receives attention is their trapping and killing of prey through the use of venom and webs. As a result, the spider is far from being a charismatic species. In the United States, 12 species of spider are listed as endangered or threatened under the Endangered Species Act.<sup>6</sup> None of these species has garnered much public support, nor are any wide-sweeping advocacy campaigns dedicated to raising awareness about their plight. The IUCN has no spiders listed because an arachnid assessment has yet to be done.<sup>3</sup> Tolkien's treatment of spiders in his literary works reflects a negative stereotype that does not help spiders to win the public's favor.

### **Conclusion**

Throughout history, authors have used animals as mediums to emphasize certain attributes or thematic elements. The roles in which these animals are cast; however, can have real-world implications. Authors often find themselves in a position of power, as they can influence a vast audience through their writings. The portrayal of animal characters, whether as being friendly or adversarial, is likely to affect the public image of their real-life counterparts. That, in turn, can influence the success or failure of conservation

# If authors were made more **mindful** of their important position, **conservationists** could gain a powerful new tool for **public education.**

campaigns for commonly anthropomorphized species. Literature offers an opportunity to modernize inaccurate negative images, encourage support of species that may not be seen as traditionally charismatic, and further important conservation efforts. Fantasy authors in particular hold tremendous power because their works often use animals to convey powerful messages to the reader. Tolkien's prominent role in fantasy literature has allowed his casting of animals as being good, bad, or ugly to further permeate our culture. If authors were made more mindful of their important position, conservationists could gain a powerful new tool for public education. Animals that have been negatively depicted could gain new life and popularity through more favorable portrayals, thereby increasing their chance for conservation success.

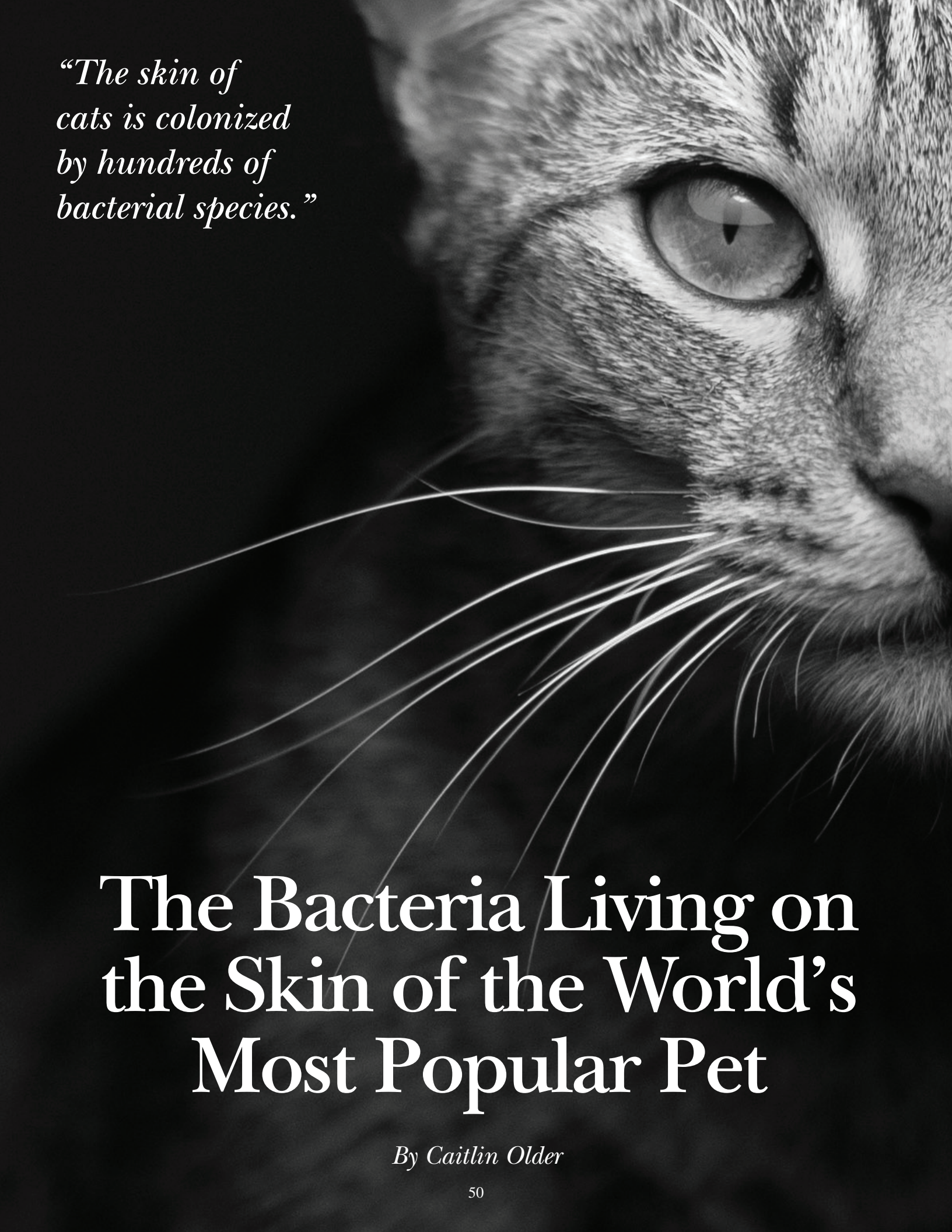
## Acknowledgments

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A close-up, black and white photograph of a cat's face. The cat's eye is visible, looking slightly to the right. Its whiskers are long and prominent, extending downwards and outwards. The fur has a mottled pattern. The background is dark and out of focus.

*“The skin of  
cats is colonized  
by hundreds of  
bacterial species.”*

# The Bacteria Living on the Skin of the World’s Most Popular Pet

*By Caitlin Older*



## Introduction

When you read “world’s most popular pet,” you might have thought I was talking about dogs. However, cats are actually the most popular pet in the world, outnumbering dogs by approximately three to one.<sup>1</sup> For those of us who do have pets, whether dogs or cats, one of our biggest concerns is their health. We worry about their diet, physical condition, and teeth—but how about their skin?

The skin of humans and our furry friends is inhabited by a multitude of microbes, including bacteria, fungi, and viruses. This community of microorganisms is known as the microbiome. Microbes can be helpful, by educating the immune system and inhibiting growth of pathogenic microorganisms, or they can be pathogenic, resulting in disease in affected tissues and damaging the host. The microbiome varies across body sites and between individuals, and imbalances in the microbial communities present can be associated with disease.<sup>2</sup>

In both humans and animals, one of the most common diseases associated with the skin is allergies (Figure 1). Most of the time, the allergen causing a reaction in the skin can be identified. For example, some individuals may experience hives with seafood or develop rashes as the seasons change. However, sometimes no allergen can be identified and treatments developed for specific allergens do not help.

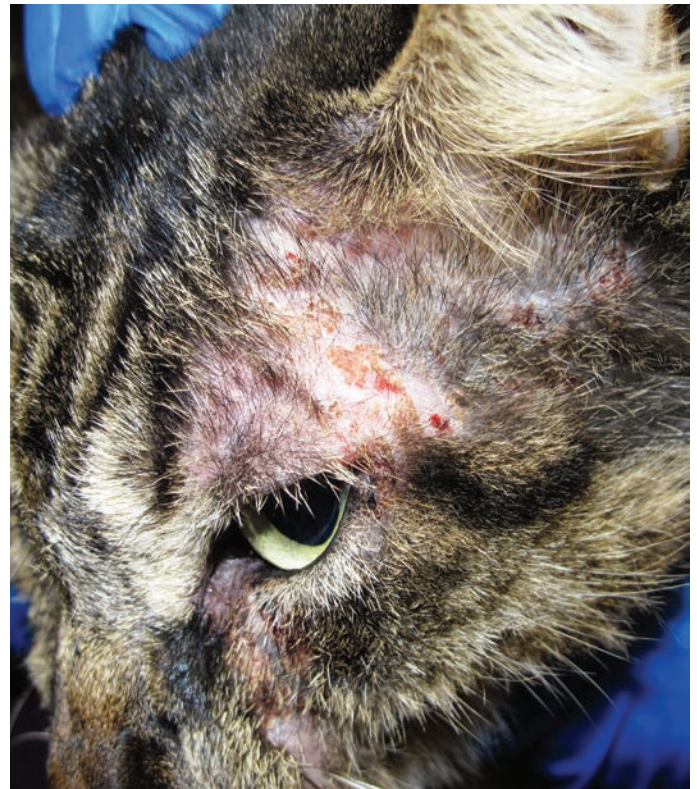
Further research on allergic skin diseases may help us better understand how allergies develop and how to treat them. We believe the microbes on the skin could be contributing to skin allergies and many other skin diseases. Allergic individuals may carry disease-causing bacteria that healthy individuals lack, or they may lack helpful bacteria that normally benefit healthy individuals. If this is the case, probiotics (such as the ones added to some yogurts to help with digestive issues) might be able to be developed for skin diseases. To do this, we first must determine the difference between what is living on the skin of healthy and allergic cats.

In our study, we set out to identify all bacterial DNA on multiple sites of healthy and allergic cats. Previous microbiome research used culture-based techniques, which involves growing the microbes in a laboratory and then identifying the bacteria on the basis of their appearance and how they live. The results from these studies are limited, since not all microbes grow well under laboratory conditions. DNA sequencing allows us to get a clearer idea of what bacteria are present in a sample, since it does not rely on the ability of the bacteria to thrive in laboratory conditions.

## Materials and Methods

Eleven healthy cats and 10 allergic cats were chosen for this study based on evaluations by veterinary dermatologists at the Veterinary Medical Teaching Hospital in the Texas A&M College of Veterinary Medicine and Biomedical Sciences. With DNA collection kits, the healthy cats were swabbed at 11 sites, and the allergic cats were swabbed at six of the same sites sampled in the healthy cats (Figure 2). Next, DNA was extracted from the swabs in our laboratory and was then sent to MR DNA, a sequencing center in Shallow Water, Texas, for bacterial sequencing.

Once we received the sequences, we processed them in a bioinformatics software, allowing us to quality filter the data and identify what bacteria are present by comparing the data with a database of known bacterial sequences. The sequences were then compared between individual cats, between different sites sampled, and between healthy and allergic cats based on two parameters: alpha diversity and beta diversity.



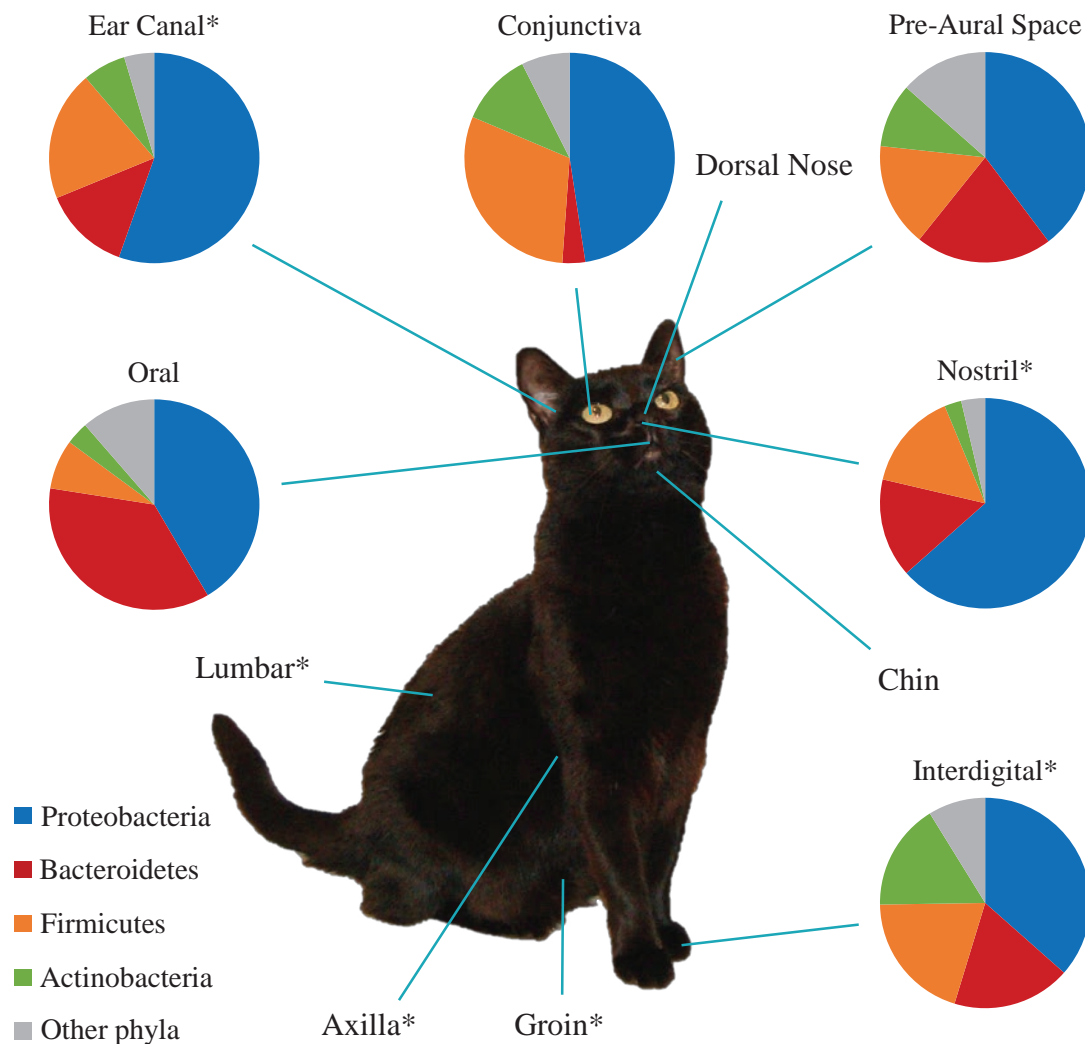
**Figure 1.** Lesions on the skin of a cat with allergies.

Alpha diversity tells us how many bacterial species are present and how evenly the species are distributed in a sample (evenness). For example, imagine a jar of 100 marbles of four different colors. If 97 of the marbles are one color, this community of marbles would not be considered even. If each color accounted for 25 marbles, then the jar would be said to be more even. Beta diversity can give us insights into how common two samples are, according to the composition of the bacterial communities. Unlike alpha diversity, which only accounts for how many species are present and in what ratio to each other, beta diversity considers what species are present and whether the communities found are similar between samples. Using this parameter, we can see whether we find the same species on the skin of healthy and allergic cats. Although we might think from alpha and beta diversity that differences are present, we cannot draw conclusions without testing for statistical significance.

## Results

We identified more than 7,500,000 bacterial sequences, which correspond to hundreds of species of bacteria. When comparing the sites sampled,





**Figure 2.** Distribution of bacteria in some of the sites sampled. Sites marked with an asterisk were sampled in both allergic and healthy cats.

we found significant differences in the number of species and the community of species. The site with the most species found and the most evenly distributed community was the preaural space, which is near the ear. The sites with the fewest species and least even distribution were the nostril and the conjunctiva (membrane of the eye). When we compared the healthy and allergic cats, healthy cats typically had more species and a more even distribution; however, that finding was not statistically significant. Overall, no difference was evident in community composition between healthy and allergic cats (Figure 2). Many specific bacteria were more abundant in healthy skin than allergic skin, and vice versa.

### Conclusions

The skin of cats is colonized by hundreds of bacterial species. The four phyla (classification level) that we found dominating the skin of cats are also the same four that occur primarily on the skin of dogs and humans, although in different proportions.<sup>2,3</sup> As expected, the microbiome is unique to each cat and even each site sampled, but shared characteristics definitely exist between sites and cats. For example, the nostrils of two cats are more similar than the nostril and the ear of one cat. In addition, we found differences between healthy and allergic cat skin. The finding of more *Staphylococcus* spp. and *Streptococcus* spp. on allergic skin is particularly interesting, since these two microbes can cause infection in cat skin. This

finding helps supports the idea that the microbes living on the skin might contribute to disease in cats.

The oral cavity had more bacteria from the phylum *Bacteroidetes* than the rest of the sites sampled. This was also the main phylum found in the oral cavity of dogs.<sup>4</sup> However, unlike dogs, cats have more *Bacteroidetes* all over their body, especially in areas that are accessible when grooming. For example, the interdigital area (the area between toes) has more *Bacteroidetes* than the conjunctiva, which cannot be groomed in cats (either by themselves or by others) (Figure 2). As cats clean themselves, they are spreading the microbes from the oral cavity to the rest of the body. This shows how the behavior of animals can affect the microbiome.

This study highlights that when we touch the skin of our furry animals, our hands are encountering an “invisible jungle” full of diverse microbial populations, which changes with disease. Learning that tens of thousands of different bacteria are on your cat might surprise you, but just as many are living on your own body and on everything around you. Not all microbes are bad, and even the ones that can cause disease don’t always do so. Many pathogenic microbes are opportunistic pathogens, causing disease only when your immune system is weakened. Most of the time, your body and some microbes can keep these pathogenic microbes at a healthy level. So do not be afraid to cuddle your feline friends.

Now that we understand what is living on the skin of normal cats, we can look deeper at the microbes on the skin of cats with different diseases and see whether a difference exists. We can bridge this research to human health in many ways. Maybe our allergies to cats are related not only to what the skin of cats is made out of or secreting, but also perhaps to some of the microbes living on their skin. Maybe our own microbiomes are shaped by that of our feline friends in a positive way. Future studies focusing on the relationship between pathogenic bacteria and skin allergies will be able to offer insights into how skin allergies develop and how to treat them. In addition, research into our microbiome and the microbiome of our pets may help us understand how to prevent diseases in humans and animals.

### Acknowledgments

I thank Dr. Adam Patterson, Dr. Alison Diesel, Courtney Meason-Smith, Dr. Tim Johnson, Dr. Joanne Mansell, Dr. Jan Suchodolski, Dr. Kimberly Wahl, and Amanda Friedrich for their contributions to this project. I also thank Tristan and Nala, the cats featured in the figures, and all cats and owners participating in the project. Thanks also to Dr. Aline Rodrigues-Hoffmann, my faculty adviser, for mentorship, guidance, and the opportunity to work on this project.

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# MEET THE AUTHORS



## Sohini Bhatia

Sohini Bhatia is a 2016 Texas A&M graduate from Plano, Texas with a degree in Food Science and Technology. She is interested in food microbiology and is attending graduate school at Texas A&M to pursue a Ph.D. before continuing on to work in research and development.



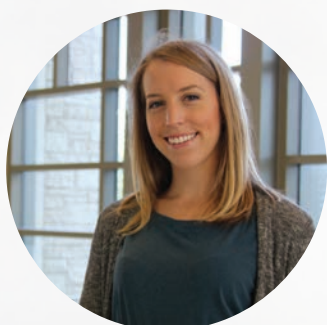
## Melissa Brumley

Melissa Brumley is a senior from Austin, Texas pursuing a Biomedical Science degree and a minor in Neuroscience. Her article is inspired by her drive to help victims of spinal cord injuries to recover from the debilitating symptoms that place a life-long burden on both the patients and their caretakers. Brumley plans to continue her studies either in the medical field or through a graduate program.



## Hunter Greer

Hunter Greer is a 2016 Texas A&M graduate from Flower Mound, Texas with a degree in Animal Science and a passion for food safety, sustainability, and infectious diseases. Greer is currently a veterinary student at the Texas A&M College of Veterinary Medicine & Biomedical Sciences and plans to pursue her research interests in infectious diseases and comparative medicine.



## Jessica Gwinn

Jessica Gwinn is a 2016 Texas A&M graduate from Katy, Texas with a degree in Bioenvironmental Sciences and Wildlife and Fisheries Sciences. Her research interests are in tracking the movement of toxins through the food chain, following them as they ultimately present in the fish that humans consume. Gwinn is continuing her research at the Dauphin Island Sea Lab to study ciguatera movement more closely before continuing on to pursue a higher degree.





## Ana Chang-Gonzalez

Ana Chang Gonzalez is a 2016 Texas A&M graduate from El Paso, Texas with a degree in Biomedical Engineering. She is intrigued by the power computers have for advancing research, specifically in the biological field. She is currently pursuing a Ph.D. in Biomedical Engineering at Texas A&M and hopes to continue onto a national laboratory or research hospital.



## Karen Galvan

Karen Galvan is a junior Nutrition major from Laredo, Texas. The inspiration for her creative piece stemmed from her passion for writing and a hope that others would take solace in her story, encouraging them to find strength within their own life struggles. Galvan plans to attend Medical School after graduation and strives to join a non-profit organization dedicated to humanitarian work such as Doctors without Borders.



## Lawson Hamilton

Lawson Hamilton is a senior from Crockett, Texas pursuing a Political Science degree and a Philosophy minor. His article is inspired by the juxtaposition of science fiction and philosophy as well as the pertinent discourse on artificial intelligence. After graduation, Hamilton plans to pursue a Ph.D. in political philosophy.



## Mary Garrido

Mary Garrido is a 2016 Texas A&M graduate from Waco, Texas with a degree in Visualization and a minor in Art and Architecture History. She has a passion for how to tell a story through history and art, allowing the audience to visualize and relive the past as we think towards the future. Garrido plans to attend graduate school to pursue her passion for advancing the way history and art is experienced in museums.



## **Dillon Jones**

Dillon Jones is a junior Wildlife and Fisheries major with a minor in Psychology from Rendon, Texas. He is extremely passionate about animals and has extensive experience working with them along with various educational and outreach programs. After graduation, Jones plans to pursue a Ph.D. in Animal Behavior, focusing on reptilian intelligence and social interaction.



## **Lauren Naylor**

Lauren Naylor is a 2016 Texas A&M graduate from Dallas, Texas with a degree in Wildlife and Fisheries and a minor in English. Naylor is currently a student at Columbia University pursuing a Masters degree in Conservation Biology. After graduation, she plans to work for a non-profit doing problem-solving research that works towards seeking solutions to human-wildlife conflicts, creating a dialogue between conservationists and community leaders.



## **Caitlin Older**

Caitlin Older is a 2016 Texas A&M graduate from Yokota Air Base, Japan with a degree in Biology. She was inspired to work on this project because of her passion for both veterinary medicine and pathobiology. Older is currently pursuing a Ph.D. in Veterinary Pathobiology and plans to also pursue a DVM.



## **Jill Palmer**

Jill Palmer is a 2016 Texas A&M graduate from Sugar Land, Texas with a degree in International Studies. Palmer plans to attend nursing school and gain clinical and professional experience before continuing to pursue an additional degree. Ultimately, Palmer hopes to pursue global public health and work on an international scale as well as continue her passion for writing.





## Alexandria Payne

Alexandria Payne is a 2016 Texas A&M graduate from Spring, Texas with a degree in Bioenvironmental Sciences and Wildlife and Fisheries Sciences. Her research interests revolve around her fascination for social insects and her experience with bee-keeping. Payne is currently a Ph.D. student at Texas A&M University in the Entomology Department.



## Carolina Pereira

Carolina Pereira is a senior from The Woodlands, Texas pursuing a degree in Visualization. She is passionate about speaking through art to inspire others to think about current events and situations happening around us and how we are affected by them. Pereira plans to pursue a graphic design career and hopes to eventually open her own non-profit organization that can provide opportunities to those that need them.



## Bailey Woods

Bailey Woods is a senior English and Classics major from Fort Worth, Texas with a passion for Greek and Roman mythology. Her research interests revolve around literature, voyage literature, Greek and Roman myth, and religion. After graduation, Woods plans to pursue a PhD in English, focusing on medieval and fantasy literature with an emphasis on creative writing.

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