

THE POISON OF MISINFORMATION:
ANALYZING THE USE OF SCIENCE IN SCIENCE FICTION
NOVELS, INCLUDING AN ORIGINAL SHORT STORY

By

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A THESIS

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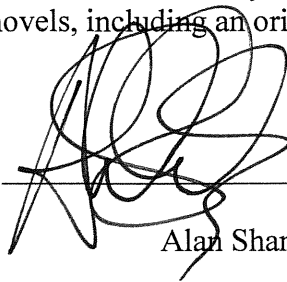
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Alan Shanks

The purpose of this thesis was to read a variety of science fiction novels and understand how the science progresses each novel. For the novels *Creature* by Peter Benchley, *The Andromeda Strain* by Michael Crichton, *Dune* by Frank Herbert, and *The Windup Girl* by Paolo Bacigalupi, I considered the role of science in relation to plot and character development. For *Jurassic Park* by Michael Crichton, I analyzed the creativity that the author used with science in addition to the role science played in the novel. For *Jaws* by Peter Benchley, I researched the accuracy of the science used and determined that the majority was accurate. With all of these analyses in mind, I created a template to guide authors in writing science fiction. Finally, I wrote my own science fiction short story, titled "Poison."

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Introduction

One of the oldest novels considered to be science fiction is *New Atlantis*, written by Sir Francis Bacon in 1627. In this book, a group of European explorers accidentally finds an island whose inhabitants have a unique culture and outlook on life. Bacon used the novel to create a utopia based on his ideas of an ideal society. It falls into the realm of science fiction because, at the time, the "natural history" and ideals on which he based his world were the epitome of modern science. These sciences were integral to the creation of his book, and so it is science fiction.

For this thesis, I am defining science fiction as a form of media, such as a film or a book, in which science plays an integral role in the plot. Science fiction has become a powerful genre in the entertainment venues of many cultures. This genre can be found in many forms of media (such as novels and movies), and it serves as a source of knowledge for anyone uninitiated in that field of science. Science fiction also considers the intricacies of mankind's relationship to science and often portrays possible future outcomes of certain areas of research, either as a cautionary tale to deter humans from that path or as a goal towards which people can strive.

A common goal of modern scientists, including biologists, is educating the public. Most museums, aquaria, and zoos further this goal by combining education with entertainment. Generally, people are more willing and more likely to learn from an experience if they were also entertained by it. Another interface between science and the public is science fiction. Though science fiction can be unrealistic and offer few opportunities for education, other examples are more realistic and people are more likely to believe the scientific content. This belief can become a problem when the

audience does not know where the creator draws the line between “science” and “fiction,” or when the creator uses incorrect science and portrays it as true. If the audience accepts this false science as fact, the creator is participating in the spread of misinformation and is being counterproductive to the general goal of public education.

The purpose of this project is to understand the way that science is used in popular science fiction novels. In some stories scientific theory is foundational to a futuristic setting, and in others modern science is used to drive the plot or develop characters. I used three different levels of analysis on the books I read; the depth of each analysis fell onto a spectrum of brief, intermediate, and close. With the findings from my analyses I formed a template of a basic science fiction story. I then used this template, conducted my own research, and wrote an original science fiction short story.

Part 1 of my thesis describes the analyses I conducted on four science fiction novels. For these I simply considered how each author used science in the overall structure of the book (e.g., character and plot development). These were all brief analyses. Part 2 details my findings when analyzing *Jurassic Park* by Michael Crichton. This was an intermediate analysis, in which I primarily considered the creative license that author Michael Crichton took with the science. Part 3 describes my analysis of *Jaws* by Peter Benchley; this was a close analysis. I researched the science in the novel for its accuracy and studied its place in the plot. This section also considers the effect of inaccurate science in the portrayal of marine animals to the public. Part 4 is the template that I created that outlines a basic science fiction story. I added the most widely used writing devices and techniques that I found in my other analyses to this template. Part 5 is the short story I wrote based on my findings.

My reading list for each section was selected with two criteria in mind. The first was simply what books were stocked at my local bookstore. Several times during the planning stages of my project I visited my favorite bookstore (Smith Family Books near the University of Oregon campus) and perused their science fiction and horror sections. I selected books and authors that I had heard of as well as those that had been recommended to me by members of my committee. The more important criterion, though, was in the book's foundational science. Many popular science fiction stories have a foundation in astronomy or technology, but the books on my reading list had to be based in biology. This criterion eliminated some of the more classic stories, such as *2001: A Space Odyssey* by Arthur Clark and anything written by Isaac Asimov. Because the basis of my education has been in biology, I restricted my thesis project to that field. I also considered my education when choosing the book for Part 3, my close analysis. Because this section required more in-depth research, I chose a book that was based on marine biology, which is my major.

Part 1

For the first part of my thesis I chose four books to briefly analyze. I read each book, noting every time science was used. Once I finished reading I summarized each book, and then considered the writing techniques and the way science factored into the story. I considered what devices were particularly effective. An effective technique is one that enhances the story, usually by engaging the reader or adding depth to a character or setting. I considered the devices I wanted to use in my own writing, and what methods I would rather avoid.

These books fell into two categories: realistic fiction in which the science is used to create tension, and unrealistic fiction in which the science is primarily used for world-building.

Realistic Fiction

The two books in this category are *Creature* by Peter Benchley and *The Andromeda Strain* by Michael Crichton. They were similar on the basis that they both took place in present day (or what was present at the time) United States. There were also some commonalities in how these books used science, though there were also many differences (which I detail below). Both novels used the device of the Uninformed Character to explain their science. Though there were characters in each book that were well-versed in the novel's science, there were also instances in which they had to explain said science to other characters that were not as knowledgeable. These are Uninformed Characters, and they allow the author to explain science to the reader without digressing from their story.

Though both novels used the science in their own ways, they had a general common ground in which the science both provided exposition and progressed the plot. The primary issue in both novels was founded in science, and so by allowing the reader to slowly understand that science the author was able to further the plot. Furthermore, the main characters in both novels were scientists, and so adding science that was not directly progressing the plot created a sturdy setting for the story.

Both novels had two climaxes; one was based more on the characters' actions while the other was a scientific reveal in which the reader finally understood the science that the author had been slowly revealing. Both novels also had their smaller understanding-based climaxes first, and had very little falling action after their larger action-based climaxes.

Creature by Peter Benchley

Near the end of WWII, Nazi scientists bioengineered a man into a creature that they hoped would turn the tide of the war in their favor. When the war ended unexpectedly, the lead scientist tried to escape with his creation, but their U-boat was attacked and the creature was lost in the Pacific Ocean. In 1966, a National Geographic photographer found its container and brought it to the surface. He opened the box and was eaten by the creature, which then returned to the sea. Once there, it began eating and killing other sea creatures as it drifted towards the coast of Connecticut. The mutilated wildlife garnered the attention of Simon Chase, lead scientist of a marine institute in Waterboro, CT, and his business partner Tall Man. Amanda Macy, another scientist who trained sea lions to film whales and other marine life, arrived with a project for Chase's institute. When a man was killed while carrying an underwater

camera, Chase brought the footage to the local sheriff and suggested that the town shut down the upcoming fair. The footage was, however, unclear; because there was no proof of a monster, Chase's requests were ignored. During a trip to sea, one of the sea lions failed to come back, and they found her camera harness on the way home. With it, they saw the creature's claw and again suggested postponing the festival. Again, they were ignored. During the festival the creature, curious about the ruckus, came on land. It expelled the water from its lungs and began breathing oxygen, but was unable to reverse the process and return to the ocean. In his search for answers Chase found a man named Jacob Franks, who was also drawn to town by the deaths and claimed to know what the creature was. He explained the WWII experiments and his own involvement as an assistant/test subject. Franks explained that they never programmed the creature to re-activate its gills, and after Chase got a report of the creature returning to the water after murdering a child, he realized that it must be swimming towards the nearest island, which housed his institute. Chase rushed back, holed up in the main building with Tall Man, Amanda, and Max, and explained that the creature was likely coming their way. Tall Man followed Amanda when she tried to save her sea lions, but they found that the creature was already there. Tall Man was attacked while Amanda ran back to warn the others. When the creature came to the building, Chase told the others to hide and tried to trick the creature into entering a decompression chamber. After a few dicey moments he succeeded, and with Amanda's help he compressed the chamber, and the creature within, and then rapidly decompressed the chamber. The decompression caused the creature to explode. They found Tall Man, who was

miraculously not dead, and brought him to the hospital. Everyone survived and seemed happy in the end.

In this book, the science was used primarily as exposition. It explained what was happening, but it rarely advanced the plot. The places in which it did, however, were crucial. In the final climax, the decompression chamber was integral (pg. 332). The creature's switch from gills to lungs was also an important element of the plot (pg. 263), though at the time this process simply occurred and was later described in scientific detail, thus falling once more into the realms of exposition. The creature itself was also based in biology and medical engineering, but again, most of this foundation was conveyed through description and history. The audience was not meant to have a previous understanding of the science involved, and most of the tension came from the actions of characters rather than scientific understanding or discoveries.

This story used the Uninformed Character technique described above. In this case, Max was most commonly the uninformed character. He was a logical choice because he was a child, and thus his lack of knowledge in the field and enthusiastic curiosity felt more believable than if the author had forced the information into the narrative for the reader's benefit. Chase also served the role of the uninformed character when Jacob Franks was explaining the origin story of the creature (pg. 296).

There were two primary sources of tension, and two corresponding climaxes, in the novel. One of these sources came from the mystery of the creature, which had some basis in science. The brief explanations that the reader got for most of the book lead them to understand that the creature was not natural and was medically engineered in some way. These descriptions, however, focused on single parts of the creature (e.g.,

claws, gills, density), leaving the reader with the urge to understand more. The audience did not see the creature (i.e., get a full visual description) until nearly the end of the book, and they got the creature's more scientific explanation around the same time. The origin story of the creature as told by Franks was the first, smaller climax of the novel. It resolved the subplot of the creature's mystery. The second source of tension was more obvious and came from the creature's actions. The more people he attacked, the more tension was built, and the more the readers worried about him attacking a character that they cared about. This plot was resolved when Chase killed the creature in the book's final, explosive climax.

The format of the book, as told from multiple points of view, allowed the author to use dramatic irony to his advantage. There were several instances in which the creature attacked something, and the readers knew about it before the other characters because they experienced it from the creature's point of view. One notable example was when Amanda was worrying about her sea lion's delayed return (pg. 221), while the readers already knew that the sea lion was dead. Another example occurred at the beginning of the book, when Chase wondered at changes in local animals' behavior. Again, the audience knew why they had changed their behavior, and so there was tension while they waited for the characters to understand as well.

Though I did not research the science in this novel thoroughly, I did notice some errors. For the most part, these mistakes were not scientific, and they may be the result of the time period in which the book was written rather than a lack of research by the author. Several of the errors I noticed were in SCUBA diving scenes; the characters called their gear flippers instead of fins (pg. 179) and used the thumbs-up sign as okay

rather than to signal an ascent (pg. 197). Both of these are taught as incorrect in most beginning SCUBA classes, but may have been acceptable when the novel was written. There were also some scientific statements that I am not sure would stand up to further research (e.g., the creature's ability to easily see both in water and on land and the entire end sequence with the decompression chamber), but without conducting said research I can only say they made me suspicious rather than that they were inaccurate. Whether these statements were accurate or not, though, they pulled me out of the narrative, which every author strives to avoid. One way to keep the reader from getting distracted may be to provide an explanation (whether fictional or real) for science that could be questioned, which this novel did not do.

There were several aspects of this book that I would like to replicate in my own writing. The Uninformed Character structure worked well at some moments in this book, though in others it became too obvious that the explanations were for the reader's benefit. Using a child as the uninformed character was particularly clever; I will likely replicate this structure in future works. The dramatic irony is another aspect of *Creature* that I wish to emulate. This device required multiple points of view, which will make it more suitable for a longer story, but allowing the reader to feel more knowledgeable than the characters creates good audience engagement.

This book also included several descriptions of characters carrying out scientific processes. Processes are a good tool to use while writing, because they involve specific action. Writers should try to write more action than explanations; for example, a phone call has less action than an in-person conversation, and so whenever possible an author should write the latter. Processes allow the writer to focus on a stream of detailed

actions, which pulls the reader further into the story. Because scientists often utilize intricate processes, such as setting up SCUBA gear or operating a decompression chamber, I hope to incorporate similar processes into my own work.

Another technique I plan to emulate from this novel is alternating the length of chapters, paragraphs, and points of view to control the speed of the story. During sections of the novel that needed to move more slowly so that the reader had time to absorb information, Benchley wrote long paragraphs and chapters, and stayed in one character's point of view for longer. During the more intense, action-filled scenes, the paragraphs and chapters were both shorter, and the reader spent less time in each point of view. In the final scene, the narrative jumped from the creature's perspective to Chase's and back again in just a few paragraphs. This method added immediacy to the scene, which benefitted the heightened tension. This level of control in a story is good writing form, and I hope to apply it effectively in my future writing.

One element that I hope to avoid in my writing is the almost prophetic foreknowledge exhibited by some of the characters. Despite having no evidence that this marine terror may suddenly become terrestrial, Chase warned against land-based attacks and, based on very little evidence, jumped to the conclusion that it had come ashore. Granted, he was correct in his assumption, but it seemed unrealistic that he could have believed in the idea so whole-heartedly with so little evidence. Because this aspect of Chase's character was not believable, I will limit the correct assumptions I allow my characters to have.

The Andromeda Strain by Michael Crichton

This novel began with a satellite being unexpectedly knocked out of orbit and landing outside the town of Piedmont, AZ. The men sent to collect it found almost everyone dead of an unknown disease, and when they entered the town they too died after seeing one living man on the street. Due to the suspicion surrounding these deaths, the government team in charge of the satellites engaged project Wildfire, which was created as a failsafe in case a satellite brought back any extraterrestrial life. Four scientists (Hall, Leavitt, Burton, and Stone) were brought into a classified base to begin studying the satellite and what could have caused the disease. This base was equipped with five levels of sterilization (with the first floor being the least sterilized and the fifth floor the most sterile and furthest underground) and an atomic bomb that would be triggered if the pathogen breached containment, thus destroying the entire facility and preventing the disease from spreading to the outside world. While Hall and Leavitt were being brought in, Burton and Stone went to Piedmont to retrieve the satellite. They discovered that the blood of most victims had all clotted and they died instantly; however, some went crazy and killed themselves in odd ways (e.g., inhaling and suffocating on rubber cement). They also found the old man and an infant still alive, and they brought them all back to the Wildfire base. While they began the process of entering the sterile environment and analyzing their data, the President decided that he would not bomb Piedmont but would instead wait to see what happened. The disease in Piedmont began to mutate and spread, dissolving polymers (including human flesh) and inducing insanity. The scientists did not find out about these things until much later. They began analyzing the satellite and the patients. On the satellite, they discovered a

rock fragment with green spots; the rock was likely a piece of the asteroid that knocked the satellite out of orbit, and the spots seemed to be growing. Upon further analysis, they found that both the rock and the spots were made of something unknown that was organic in origin and contained no amino acids. The scientists also discovered that the spots, which they assumed were a sample of the disease, flourished in carbon dioxide and was poisoned by oxygen. They then studied the patients, and determined that the baby was in perfect health, and the old man suffered from ulcers and had been acidifying his blood to help fight the pain. Further studies of the pathogen led the scientists to understand that it was airborne and about the size of a cell. They discovered that the organism converted matter directly to energy and vice versa, so once they re-established contact with the outside world they suggested against nuking the town. They eventually realized that, though blood clotting killed some of the pathogen's victims, the rest died because of brain hemorrhaging. Soon thereafter, the pathogen began degrading the lab's polymers and caused a seal breach in the autopsy area. The area was sectioned off and Burton was trapped. He did not die immediately, and Hall realized that there was a limited blood pH in which the organism could live. He told Burton to hyperventilate and thus acidify his blood until they could find another solution, but then realized it must have been a mutated, non-lethal form of the organism because Burton did not die immediately after exposure. Polymer degradation continued until the entire floor was contaminated and the emergency atomic detonation was triggered. Hall, who was the only member of the science team with the authorization to turn off the emergency detonation, was trapped in a section of the facility without a key box, and thus without the ability to stop the bomb. He had to climb through the central duct of

the facility to the floor above in order to turn off the bomb countdown there while emergency protocols intended to contain the organism shot sedatives at him. Everyone survived the process, and the scientists realized that the organism had mutated into an entirely benign form and would likely return to the upper atmosphere to escape our oxygen-rich air.

This book was written as if it were a case report of events that actually occurred, and thus it was written by a retrospective narrator. It also contained a lot of history and descriptions, using the reader as the Uninformed Character. This method did not feel like a break from the narrative, however, because the readers understood by the end of the first page that the purpose of the novel was for them to understand the events of this phenomenon. Science was also used much more heavily in the plot than in *Creature*, and extended to including scientific figures and raw data (pg. 192, 247, 305). Crichton also wrote an acknowledgements section and a bibliography for *The Andromeda Strain*, both of which are filled with fictitious names and articles, but added realism to the piece. He blended fact and fiction without giving any indication of a difference. The tension resided in the author's foreshadowing and in the unknown that the scientific processes were supposed to reveal.

Like *Creature*, this novel featured a dual climax. The first was understanding the organism, and came directly from science. The second was in Hall stopping the nuclear device, but the emphasis was put not on saving the characters' lives but on keeping the organism from spreading and multiplying on the energy of a nuclear blast. Though the second had a heavy base in character action, most of the weight behind the action was in science. The writing was also more technical in *The Andromeda Strain* than in

Creature, and the entire novel had credibility because of it. *Creature* used science to embellish a story that was obviously fiction, while *The Andromeda Strain* treated the science and the events as fact.

This novel was more idea- than action-driven. Theories were almost more important to the progression of the story than characters were. That being said, the pathogen became a character in and of itself, and what it would do became the primary tension in the story. Furthermore, because the theories and ideas were elevated to such importance, scientific discoveries took on an important role in resolving tension, while in most stories action is the primary vessel for resolution. Though there was action in the processes of testing the organism to better understand it, the real excitement of most of the book was in the discoveries at the end of the tests and what they would reveal about the organism. Crichton's descriptions of these processes further benefitted the novel by keeping the story immediate for the reader.

In my writing, I plan to implement the way that Crichton used the retrospective narrator to create foreshadowing. In several instances, characters did something mundane; readers would not have considered these actions twice, except that the actions were followed by the narrator mentioning what a colossal mistake they were and how no one would realize the errors until much later (pg. 194). After that, the readers wanted to understand why something so basic was such a bad idea, and it drove them to continue reading in order to find out. The audience also knew that some of the scientists would survive early on, as the author "interviewed" them before writing the story and mentioned these interviews in the narrative (pg. 78). This device piqued the reader's interest, because there were times they did not know how any of the characters were

going to survive; however, it could also decrease tension in certain moments if used incorrectly. For example, if you remember that Stone would survive this event (pg. 78), then you also know that the bomb at the end cannot explode, because it would kill Stone. In this case, knowing Stone would survive did not ruin the tension of the scene because 1) his survival was mentioned much earlier, so it is possible the reader got distracted by the intense scene and forgot, and 2) even if the reader remembered, the likelihood of the bomb exploding was so high that the new tension would come from wanting to know how they could possibly prevent it from happening, or how Stone would survive if it did explode.

I am also intrigued by the idea of writing a science fiction story that could have happened in our reality, without any alterations. Because nothing explosive ultimately happens in *The Andromeda Strain* and everything is covered up by the government, it could conceivably have happened in our version of the world. I think it would be more difficult to write a story like this, with so much secrecy and so many rules to fit into, than to write a story in which the history of our reality is altered from some event in the past, in which the writer could use creative license to make up their own rules for the world. Writing in a setting with established rules is a challenge that I want to undertake in my future work.

Unrealistic Fiction

The two books in this category were *Dune* by Frank Herbert and *The Windup Girl* by Paolo Bacigalupi. They fall into a more classic template of science fiction, in which the setting is not reality as we know it. In these books science was integral to the world that the authors built; they mixed scientific theory and principles with creative

license and used it as the foundation for their settings. In both books, the culture depicted revolved around one or two simple scientific principles that are entirely understandable to today's scientists. Like in the realistic fictions, the science was necessary to progress the plot for both stories. This need, however, had more to do with the plots occurring in fantastic, science-based settings than with scientific anomalies driving the plot, as we saw in the previous realistic fictions.

I think the most interesting commonality between these two books was that they both created religions to go with their realities, and both religions had a basis in science. In *Dune*, the Bene Gesserit religion blended the mystical with sciences like chemistry, biology, and psychology. Those taught in the Bene Gesserit ways could accomplish things like neuroenticement (pg. 421), cold reading (pg. 459), and psychokinesis (pg. 507). They also studied eugenics and tried to manipulate politics through long-term breeding projects (pg. 785). Ultimately, the Bene Gesserit religion was important in the plot development of *Dune* because the main character fulfilled several of their prophecies. Though not as important to the book itself, Bacigalupi also included religion in *The Windup Girl*. This faith was a futuristic branch of Christianity that focused on niches (pg. 91), which is an ecological concept. Like many religions, this community divided into radical and non-radical believers, and the radicals were known for their field-burnings at facilities growing genetically engineered crops (pg. 91). Though this religion was not entirely fictional and was based on a common religion in our world, the author's portrayal of Christianity in a futuristic setting had a basis in science. It is unsurprising that these books created religions within their realities, as

faith is integral in so many non-fictional cultures. Adding a religion based on the culture would add depth and believability to the world, which further engages the reader.

Dune by Frank Herbert

The novel *Dune* was written in three parts. Book I opened with the Atreides family preparing for their departure for Arrakis, the desert planet also known as Dune. The Duke Atreides had been ordered by the Emperor to rule the planet, and he agreed to do so despite the fact that its previous rulers, the Harkonnens, were bitter rivals of the Atreides family and would likely attempt to kill them when they arrived. Before leaving, Paul Atreides (the Duke's only child) was visited by the Reverend Mother, who was a leader of the Bene Gesserit religion and mentored Paul's mother Jessica in their ways. She informed Paul and Jessica that Paul might have the mystic abilities of the Bene Gesserit, which was unheard of in males. It was possible that Paul would fulfill a prophecy regarding a male Bene Gesserit, but only time would tell. Part of the preparations included the family doctor Yueh readying himself to betray the Duke, as Yueh was a being blackmailed into killing the family by the Harkonnens. There was a time gap in which the family was travelling, and the narrative picks back up several years later upon the Atreides' arrival at their new home on Dune. They began meeting locals and learning more about the planet, which included visiting a factory that harvested the planetary resource spice. The spice was culturally important on Dune as it was incorporated into nearly all meals, and frequent exposure turned one's eyes entirely blue. The Duke was especially interested in a relationship with the Fremen, an indigenous race that lived in the wild deserts of Dune. Before he could bring this plan to fruition, though, Yueh snuck Harkonnens (who were aided by the Emperor's soldiers)

into their home. Paul and Jessica escaped into the desert, but the Duke and Yueh were killed and the Harkonnens regained control of the planet. During his escape, Paul unknowingly activated his Bene Gesserit abilities, and thus began fulfilling the prophecy.

Book II began with Paul and Jessica trying to survive the desert. Paul's new abilities, enhanced by his spice-diet, allowed him to not only consider hundreds of possibilities at once but also to actually see versions of the future. He also realized before she could that Jessica was pregnant with his future sister. They were found by a group of Fremen; among the group were the tribe leader Stilgar and a young woman named Chani. Another member of the tribe challenged Paul to combat, and so Paul was forced to kill him, thus creating a place for him and his mother in the tribe. They learned that the Fremen had basic Bene Gesserit training, and had prophecies that could refer to both Paul and Jessica. They returned to the tribe's home and met the Fremen's Reverend Mother, who believed Jessica was supposed to replace her. Jessica went through the test, drinking a spice-based poison. She used her Bene Gesserit skills to manipulate the poison at the molecular level, adding a catalyst that turned it into a harmless drug instead. By doing so she passed the test, guided the old Reverend Mother through her death, and became the tribe's new Reverend Mother. They dispersed the drug through the tribe, and it allowed the Fremen to have some visions of the future. The drug especially enhanced Paul's abilities, and he and Chani realized that they would develop a relationship over the years. Book II ended with them consummating their relationship.

Book III began several years later, when Paul and Jessica had become established members of the tribe. Jessica had given birth to her daughter and named her Alia. Paul and Chani had become partners and had a young son. Paul had to pass a Fremen rite of passage to become fully a member of the tribe, even though he already had an army of devoted (and fanatic) followers. To no one's surprise, he succeeded. Afterwards, he also secretly took the test of the Reverend Mother, survived, and fulfilled the final step of the Bene Gesserit prophecy. In the process he had a vision that showed him how he could destroy all the spice on the planet, which would kill anyone who had become dependent on the spice in their diets (including the local political powers that supported the Harkonnens). Paul, Chani, and Jessica received news that their home base had been attacked by the visiting Emperor. Paul and Chani's son was killed and Alia was kidnapped. This news pushed Paul to attack the Emperor's temporary base, where Alia was being held. During the attack, Alia killed Duke Harkonnen, and the Emperor decided to negotiate with Paul and the Fremen. Ultimately, the Emperor agreed to let Paul marry his daughter and heir, making Paul the future Emperor. The other political powers involved in the struggle quickly agreed with Paul when he threatens to destroy the planet's spice.¹

This novel, including the "science" it used, was very complex. What Tolkien did with language, Herbert did with ecology. He built a very complex and detailed world that readers only see a fraction of in this book. To create this world he used real, foundational ecological theories (pg. 222, 225, 438) and built upon them. He centered

¹ If this story interests you at all and you have not read the book already, I highly recommend you do so. My incredibly brief description does not do it justice.

the culture of Dune around the need for water conservation and the chemistry of the spice. Once he had this base he took a step further and added some paranatural elements; though most of the Bene Gesserit training was based on psychology, biology, and chemistry, there were some supernatural elements like prescience (seeing the future) and psychokinesis (pg. 327). He rarely explained anything directly; rather, he documented the characters' natural behavior and dialogue, very subtly structured to give the reader all the information they need over time (pg. 360). Discovering the secrets of the world became a sub-plot in and of itself, with tension and some resolution (even if the reader did not understand everything by the end).

Though most of the time the author did not directly reveal knowledge to the reader, there are some instances of the Uninformed Character structure, in which Paul and Jessica were the uninformed characters. When they first arrived on Dune, they knew only slightly more than the reader about its ecology. As they learned, primarily from Dune's planetologist (who we would call an ecologist), so did the reader. One scene, however, broke from the subtle structures entirely. In Book II, the planetologist was dying in the desert and suffered from hallucinations (pg. 438); during this scene the narrator explained several concepts directly to the reader. Though normally this method of exposition is less effective than techniques that require the reader to be active, this scene worked without boring the reader because none of the explanations were complete. Though it was all information that the reader would need eventually, the explanations were only pieces of the overall puzzle, and so giving them to the reader so easily still maintained the tension of the unknown and pushed the audience to keep reading in order to learn more.

The two things I am most likely to steal from this book are its rich and complex world and its use of point of view in tense moments. Herbert took the care of an artist in crafting this work, and it shows. The interwoven webs of the ecology, religion, politics, and culture are admirable, and someday I hope to create a world that is even half this intricate. The author's use of point of view is another aspect worth replicating. He used it well throughout the book; just as the readers would get deeply involved in one narrative, it switched to another. As in *Creature*, Herbert used point of view to speed up intense, climactic moments. Rather than simply going between two points of view, Herbert used six in his final scene (pg. 766). Not only did these short points of view add immediacy to the moment, they also created a fitting sense of resolution that the rest of the book had been leading up to. Part of the driving force of the story was the unknown; when the readers only understood part of what was going on in each scene, they were pushed to keep reading in order to understand more. In the final scene, though, the thoughts of the most important characters were explained in detail, and so the reader finally got a feeling of clarity and understanding just before the book ended. It was a fitting way to conclude *Dune*, and I hope to bring that level of understanding to my future works.

That being said, this novel often toed the line between interestingly complex and confusing. The final scene was an example of this possible issue. There were so many points of view, and paragraph breaks were the only indication that the perspective may have changed; furthermore, since the perspective did not change after every paragraph break, the readers had to wonder for the first several sentences of each paragraph if the point of view had changed. For some readers, this structure could have been too

complex and may have slowed the scene rather than added to it. This is only one example of intricacy bordering confusion in *Dune*, and I hope to avoid this problem in my work. Furthermore, by the last page the readers did not understand everything that had been hinted at throughout the novel, which made the audience aware that that they had only scratched the surface of everything there was to know about Dune. Though it was understandable that such a complex world could not be fully revealed in a single book, there were some issues (such as the relationship between the worms, the spice, and the planet's water supply) that were only partially revealed by the end of the story. Though Herbert likely avoided resolving everything in order to encourage his audience to read the sequels to *Dune*, I found it frustrating that after eight hundred pages the readers were not given a more thorough understanding of issues that seemed so important to the story, and in my work I hope to refrain from leaving my audience with a similar feeling.

The Windup Girl by Paolo Bacigalupi

This novel opened with Anderson Lake buying a *ngaw* fruit from a black market stall on the streets of Thailand. This fruit was no longer supposed to exist and had been brought back from extinction by the Thai government. Anderson ran a company that manufactured springs, as nearly everything in this world ran on spring-power. This company was a front, however, and Anderson was actually searching for the Thai government's seed bank. He worked for a Calorie Company, which sold non-fertile crops and produced diseases that killed crops from competing companies. Some of these diseases mutated out of control and plagued the world. In the process of trying to find this seed bank Anderson met Emiko. Emiko was a genetically engineered person

known as a windup girl. She was brought to Thailand and abandoned there by her Japanese master, and had since become an attraction at a brothel. Anderson told Emiko of villages where windups live free of masters, and this became Emiko's new dream. Meanwhile, there was unrest between the two parts of the Thai government: the Environment Ministry and the Trade Ministry. Jaidee, a captain in the Environment Ministry, believed there was too much corruption in both factions and so began fighting to end the bribery and blind eyes. He lacked any subtlety or tact, and his actions angered the Trade Ministry. They kidnapped his wife to encourage him to cooperate, and when this ultimately did not work they killed him brutally. His partner Kanya was promoted to captain, and he became a martyr for the Environment Ministry. A third party set up a meeting between Anderson and the leader of the Trade Ministry, Akkarat, as well as some of his allies. Anderson agreed to provide them with the military power to wipe out the Environment Ministry if they would provide him access to their national seed bank. They were unconvinced until Anderson promised to show them something unique, and brought them to one of Emiko's shows at the brothel to prove that he could keep his word. Anderson and Akkarat left, but the rest of the Ministry's associates stayed and paid the brothel owner for time with Emiko. After they took advantage of her, she snapped and killed them all, then ran to hide in Anderson's apartment. Akkarat assumed that Anderson planned for Emiko to kill them, and so brought him to the Trade Ministry by force and began the coup earlier than planned. Anderson convinced Akkarat that he had not been trying to trick them, and they agreed to a new deal. The Environment Ministry was destroyed, leaving only Kanya and the team that was with her, who all agreed to join the Trade Ministry. Before he could celebrate the victory, Anderson

caught one of the mutated crop diseases, and so Akkarat abandoned him to die while Akkarat negotiated a deal with the Calorie Company. When representatives from the company arrived, Kanya was ordered to show them the seed bank. Instead, she killed them and helped the monks at the seed bank hide the seeds. She and her team then broke the water pumps at the city wall, which allowed the rising sea level to flood and destroy the city. Emiko took care of Anderson until his death, and then decided that the flooded city was the perfect place to start a new Windup village.

Much like in *Dune*, the science in *The Windup Girl* was integrated into the story's setting. Rather than creating an entirely new system of planets, Bacigalupi wrote about a future of our reality, in which sea level rise (pg. 7), genetic manipulation (pg. 26), and food shortages (pg. 2) have become the focal points of human existence. Personally, I did not like this book. I thought it was unnecessarily violent, dark, and sexist (this last problem actually makes sense in the dystopian world that Bacigalupi created, but the issue was not addressed as being wrong while nearly everything else was). I probably would not recommend it without first warning the reader what they were getting into. Despite these problems, I can admit that the novel was well-written. The number of unexpected turns in the plot keeps the readers guessing until the last page, and the world was chilling in its future plausibility. Every instance of scientific progress that Bacigalupi portrayed as futuristic is actually possible or nearly possible with today's science. Companies that control and genetically manipulate food already exist; they would simply have to abandon morality to become the Calorie Companies of *The Windup Girl*. This novel delivers both entertainment and a warning: do not let our world become the world in this story.

As has been the case with several of the previous books, this novel used dramatic irony well. The characters did not all interact, and so by the end of the story only the reader knew everything that had happened. Though the irony was sometimes obvious, through most of the book it was subtle. For example, when a scientist was studying a new disease (that ultimately killed Anderson) she mentioned that it was highly mutated and must have gone through thousands of generations to reach that degree of change (pg. 217). If the reader made certain connections, they could realize that this rapid evolution must have been a result of the disease growing in the algae, which had a quick generation period, though the characters never made this discovery. Using dramatic irony in this fashion takes a careful and manipulative hand, and it is what I most want to take from *The Windup Girl* and apply to my own work.

One aspect of this story that I want to avoid replicating in my writing is the gratuitously detailed scenes of sexual assault. While I agree that they furthered the tone of darkness in the novel and amplified our hatred for certain characters, I feel like the same effect could have been achieved while being more subtle. The terminology used during the scenes made them feel cheap and out of place in the otherwise well-written book (pg. 38, 256). Furthermore, the content of these scenes could be very triggering for some readers, and I would hope to avoid alienating or harming members of my audience in that way. Bacigalupi was clearly writing for the shock factor when crafting these scenes, while I feel like the point to a scene should be based in furthering plot or character development, which again could have been done without the full detail involved in this book.

Part 2

For the second part of my thesis I read *Jurassic Park* by Michael Crichton. Originally I planned to complete the same kind of close analysis on *Jurassic Park* that I did for *Jaws*. After starting this process, I realized that much of the science was paleontology, and that I was out of my depth. Though I knew paleontology would feature heavily in the book when I began, in my planning stages I treated paleontology simply as biology for dinosaurs. I soon learned that this was not the case, and thus scaled back my analysis for *Jurassic Park* in order to fit into my remaining time and personal capacity. Therefore, my intermediate analysis for *Jurassic Park* included cursory research regarding the accuracy of the science and a more in-depth study of the creative license Crichton took with science and the writing techniques he used.

Like *The Andromeda Strain*, *Jurassic Park* was portrayed as an actual event, though not to the same degree. While *The Andromeda Strain* was written as if it were a case study, *Jurassic Park* was written in the basic prose narrative form. This narrative, however, frequently called on history (both fictional and real) to establish itself in the reality of its time (pg. 45, 119). The novel portrayed its content as an event equal to the historic occurrences it mentioned. Because of the isolated nature of the island setting and the secrecy involved in the project as a whole, the catastrophic events depicted could have occurred without the general public's knowledge. Some problems arise with this framework at the end of the book, when velociraptors and compys have escaped to the mainland (pg. 399), but even then the escapes are being covered up. The solid basis in reality benefits the reader's experience, because it adds the frightening (if fictional)

and intriguing possibility that these events could happen in the world as the reader knows it.

Creative license vs. scientific accuracy

When writing this book, Crichton liberally used creative license with the science. Though he also conducted thorough research, there were a number of aspects to the story that he made up entirely. For example, Crichton described a disease caused by lizards called central saurian encephalitis, which was supposed to cause sleeping sickness in humans and horses (pg. 21). He also mentioned gamma-amino methionine hydrolase, which one scientist found in the DNA of a dinosaur and described as a marker included in genetically engineered animals (pg. 27). Later in the book Crichton provided a brief (though detailed) life history for the plant *Serenna veriformans*, including its period of origin and current known range (pg. 85). All three of these (the disease, the marker, and the plant) are fictional, made up by Crichton to embellish his book. The potential problem with this decision is that he did not distinguish between what he had found in his research and what he was fabricating. He wrote his fictional science with such confidence and so much detail that it seems just as true as the accurate science in his book. Though even these made-up descriptions must have required significant research, if only so that he knew what details to add, it may have benefitted his readers if he had used actual diseases and plants as embellishments to his story. There are many prehistoric plants from which Crichton could have chosen. Fabricating a new plant may have been the easier choice. By creating a make-believe plant, the author gets to choose its details rather than being restrained by the facts that already exist for real plants. Furthermore, there is no one to hold the author accountable

for getting specifics wrong if the plant is of their own creation, while some members of the audience (such as myself) would likely complain if the author incorrectly portrayed a real organism. Portraying the fictional plant as real, however, was deceptive and provided misinformation to the readers. In this case, it is not a serious problem; public misinformation on prehistoric plants will not greatly affect paleobotany. In other areas of science, such as biology and zoology, public misconceptions could be damaging to extant populations of creatures.

On the other hand, Crichton's bold statements of fictitious science and lack of distinction between fact and fiction created a compelling and realistic setting. He mentioned names and events, used "direct quotes" from articles that may or may not have existed (pg. 72). Many of these statements would be easy for the readers to simply look up. Though most of the audience would not go through the trouble (especially when, in the 1990s, it would have included going to a library rather than opening Google), the fact that Crichton provided information that could be verified boosted the confidence that readers had in this information. The detail and clarity of the science, as well as the information's accessibility, created an aura of confidence around Crichton. When the author provides "facts" with such confidence, the reader feels more confident in the imaginary world and becomes more involved in the story.

Crichton also alerted his audience in several instances that he was diverging from accepted paleontological discoveries. His dilophosaurs could spit poison, but he mentions that scientists had discovered no evidence for this trait before they resurrected the animal for Jurassic Park (pg. 146). One character noted that apatosauruses were walking on land, though all literature to that point assumed they preferred marshy

habitats to help compensate for their mass (pg. 151). Near the end of the book, a character realized that the velociraptors had a highly developed sense of smell, despite the fact that all the books said dinosaurs had a poor sense of smell (pg. 330). These alterations make sense, because as the paleontologists in the book note, it was unlikely that they had gotten everything right (pg. 375, 394). Though the differences from accepted science could have discredited Crichton and show his readers the author behind the curtain, he framed the changes so that they seemed natural and logical.

There were some aspects of the book that Crichton chose to make up, but there were other elements that he was forced to. Though paleontologists can tell us a surprising amount about dinosaurs, there were some things at the time *Jurassic Park* was published of which not even life-long scholars could be sure. One of these was the behavior of dinosaurs. Because Crichton wrote about extinct species, he could fill in the information gaps with anything he wanted. Some things like behavior could not have been known with any certainty, and so the author had lots of wiggle room. This black box of paleontology, along with the acknowledgement that paleontology is fallible, created a safety net for Crichton in which nearly all of his inaccuracies could be caught.

Despite his many manipulations of science, Crichton had a diverse scientific base upon which to base *Jurassic Park*, including biology, chemistry, math, computer science, and paleontology. Not all science referenced in this book was fictional. To so realistically create the scientific details that he fabricated, Crichton would have needed a thorough understanding of how the real science worked. For example, to understand how to write a believable life history of a fictitious plant, he would have had to understand the components of a real plant's life history. Crichton continued putting this

level of detail into all the science in *Jurassic Park*. Though I did not research it, Rossman (1994) analyzed Crichton's use of mathematics and statistics. Though he condemned many of the graphs for being too perfect (a natural system would have more variation), he acknowledged that Crichton used the concepts correctly and that they benefited the novel as a whole. Crichton wrote biology into his novel in much the same way, by creating a template using true scientific theory and filling it in with his own creativity.

Writing Devices

Crichton villainizes his antagonists, which by the end are primarily the velociraptors. Though I detail the problem of villainizing animal antagonists in Part 3, Crichton managed to avoid it being a problem through several decisions. First, though he created the possibility that all velociraptors had the potential for evil (pg. 147), this stigma did not have a negative impact on actual populations of animals because the animal in question is extinct. By putting this stigma on animals that no longer exist, Crichton avoided the problem of stigmatizing an entire species that his audience may then have to interact with in the real world. Second, by the end of the novel the velociraptors are shown to have a rather benign goal. They want to escape the island, not because they want to go on a killing spree, but because it is their instinct to migrate (pg. 395). This decision removed them from the personifications of the rest of the book and returned the audience's perspective of them to simply animals. Though it could not entirely negate the clever and intentional violence seen already from the velociraptors, ending on this note left readers with the idea that maybe the velociraptors were not so bad after all. The ending also created some sympathy from the reader for the

velociraptors. The raptors were pulled out of their own time and forced to live in this world in a very restricted setting. Though, of course, they should be killed because they did not belong in the modern world, it gave the audience the idea that the velociraptors were not entirely at fault for their behavior.

There were several devices in Crichton's writing that I plan to apply to my future work. He was a master at creating realistic fictitious settings, and his stories' verisimilitude makes each of his books engaging and compelling. Using techniques like fabricated "direct quotes" and thorough details, I hope to achieve this same tone in my writing. Like several of the previous novels, *Jurassic Park* also used dramatic irony to great effect, and I plan to learn from their examples. Each character had a limited perspective, but because the readers got to experience multiple perspectives, they usually knew more than the characters. This structure is similar to those detailed in Part 1, but it bears repeating because it is both a popular and effective writing device. Engaging the reader is the ultimate goal of any author, and frustrated readers yelling ineffectively at the less-informed characters is a good example of engagement. Yelling at the characters implies that the reader cares about their well-being, which is the mark of a well-written story.

I also hope to use Crichton's research techniques in my writing. His primary sources of information (according to his Acknowledgements) were professionals in the field. Experts would likely be the best sources for science fiction writers to utilize. Though scientific papers and books give accurate facts, actual scientists can give experiences, which are more vivid and active. They provide a level of depth to the

world that simple knowledge would not, and so I will endeavor to include experiences alongside information in my research.

Though it was compelling to research how Crichton blended fact and fiction so seamlessly, this is an aspect of his work that I will try to avoid in my science fiction. He was incredibly good at what he did, but as a scientist as well as a writer I would rather not be a source of misinformation in the world. Though my science fiction story in Part 5 will not be entirely accurate, I will try to use the framework of acknowledging the inaccuracies in science and providing a reason for them rather than bluffing my way through and convincing my readers that they are accepted scientific facts.

Part 3

In the third part of my thesis, I conducted a close analysis of the novel *Jaws*. After its publication and subsequent cinematic debut, *Jaws* supported the view of sharks, especially white sharks (*Carcharodon carcharias*, Lamnidae), as vicious man-eaters (Benchley 1974). Many scientists and conservationists have since worked to change this opinion (including *Jaws* author Peter Benchley), though white sharks are still frequently portrayed in media as mindless killing machines. In this part of my thesis, I researched the accuracy of the science used in the novel *Jaws* to determine its contribution to public misinformation. I hypothesized that the majority of the science used in the novel would be inaccurate.

Methods

I read *Jaws* and noted each time that science affected the plot or characters. I then collected these notations and sorted them into six topics: shark feeding behavior, shark swimming behavior, white shark physiology, other shark biology, other general biology, and anomalies. I researched each statement in the first five categories to determine its accuracy as: accurate, inaccurate, or inadequate evidence. Inadequate evidence indicates that there is a lack of scientific material, and so the statement could be either accurate or inaccurate and further research would be necessary to determine which. This category could also indicate that the statement is not testable, and so cannot be supported or denied. I did not research the accuracy of the statements that fell into the category of anomalies because the characters themselves acknowledge that the anomalies should not be true. I counted the total statements and made two pie charts:

one representing the percentage of accurate, inaccurate, and inadequate evidence statements, and one representing these in addition to anomalous statements.

In this type of analysis, one must consider the science available at the time the piece was written in order to give an accurate portrayal of how the author used science. For example, if an author wrote a book stating that deep-sea arthropods were black and several years later it was discovered that they were red, the author could not be faulted for their original story because they could not have known their science was inaccurate. Thus, I limited my research to pre-1974 scientific literature.

Results

There were thirteen scientific statements in the category of shark feeding behavior (Table 1). Of these, nine were accurate and four had inadequate evidence. There were no inaccurate statements in this category. An example of an accurate statement from this category was, “Sharks swallow without chewing.” One of the statements without adequate evidence was, “Swimming on your period could instigate a shark attack.” Though there are casual, non-peer reviewed sources (such as blogs) claiming this idea is false, there have been no tests or research conducted to formally disprove the statement. Several of the statements labeled with inadequate evidence in this category could be supported as accurate with papers written post-1974, but I could find no sources from 1974 or earlier supporting the statements.

Table 1: The statements and research in the category shark feeding behavior.

Statement	Citation (page in Benchley 1974)	Accuracy	Source
White sharks will attack and eat anything they can swallow, and will regurgitate non-food.	Opening quote, 53, 90, 239, 300, 301	Yes	Budker 1971
Tremors sometimes shake a shark while hunting.	5	Inadequate evidence	
Sharks sometimes circle their prey before attacking.	5	Yes	Budker 1971
Sharks swallow without chewing.	6	Yes	Budker 1971
Sharks shake their heads to cut their prey.	6	Yes	Moss 1972
White sharks have been recorded attacking from below and breaching.	5, 6, 53	Inadequate evidence	
Some sharks that attack people are tiger sharks, hammerheads, makos, and blue sharks.	36	Yes	Budker 1971
Two reasons that sharks attack people are hunger or confusion because they smell blood in water.	36	Yes	Budker 1971
Swimming on your period could instigate a shark attack.	37	Inadequate evidence	
Shark longevity and instincts are largely unknown.	117	Yes	Budker 1971
Gutted sharks can still swim and potentially eat their own viscera.	234	Yes	Budker 1971
White sharks prey on porpoises.	241	Yes	Arnold 1972
White sharks can have the jaw strength to bite through a wire fishing line, and could bite through a dog chain leader with time.	250, 251	Inadequate evidence	

There were seven statements in the category of shark swimming behavior (Table 2). Of these, three were accurate, one was inaccurate, and three had inadequate evidence. One example of an accurate statement in this category was, “Sharks swim by sweeping their caudal fins for velocity and adjusting their pectoral fins for direction.” The inaccurate statement was, “White sharks are comfortable in water around 10° C, but not in water around 20° C.” One statement that lacked evidence was, “A white shark’s presence can drive off other fish.”

Table 2: The statements and research in the category shark swimming behavior.

Statement	Citation (page in Benchley 1974)	Accuracy	Source
Sharks swim by sweeping their caudal fins for velocity and adjusting their pectoral fins for direction.	3, 5	Yes	Budker 1971
Sharks often have their mouths slightly open.	3, 252, 253, 275, 299, 304	Yes	Moss 1972
White sharks are comfortable in water around 10° C, but not around 21° C.	36, 37, 178-9	No	Kato 1965
White sharks will swim near the bottom in water 26 meters deep or shallower.	52, 53, 208	Inadequate evidence	
On the East Coast of the United States, sharks are less common in early spring than summer.	69	Yes	Scattergood 1962
A white shark’s presence can drive off other fish.	124	Inadequate evidence	
Sharks will lift their heads out of the water, including eyes, when something interests them on the surface.	252, 253, 275, 299, 304	Inadequate evidence	

There were twelve statements in the category of white shark physiology (Table 3). Of these, six were accurate, five were inaccurate, and one had inadequate evidence. One of the accurate statements was, “This specimen [from the novel] was about 6 m

long.” One of the inaccurate statements was, “An Australian white shark was measured at 11 m long.” All of the inaccurate statements in this category involved the possible size of white sharks, and these statements were all determined inaccurate by a paper released in 1973. The statement that lacked evidence was, “*Megalodons* may be large versions of white sharks.”

Table 3: The statements and research in the category white shark physiology.

Statement	Citation (page in Benchley 1974)	Accuracy	Source
Sharks do not predominately use vision to swim.	3	Yes	Budker 1971
Sharks can recognize prey (struggling) by detecting vibrations in the water.	4, 5, 53	Yes	Budker 1971
White sharks can grow to over 9 m.	Opening quote	No	Randall 1973
This specimen was about 6 m long.	62, 89, 253	Yes	Randall 1973
The mouth was about 0.9 m wide (diameter of bite).	36, 82	No	Randall 1973
The tooth was nearly 5 cm long.	84	Yes	Randall 1973
From tooth, the shark could be identified as a white shark and estimated at 4.5-6 m long and 2300-2700 kg in weight.	89-90	Yes	Randall 1973
The head was about 1.2 m across.	252	No	Randall 1973
An Australian white shark was measured at 11 m long.	255	No	Randall 1973
A <i>megalodon</i> 's fossilized tooth can be 15 cm long.	256	Yes	Randall 1973
This tooth size puts the <i>megalodon</i> between 24 and 30 m.	256	No	Randall 1973
<i>Megalodons</i> may be large versions of white sharks.	256	Inadequate evidence	

There were six statements in the category of other shark biology (Table 4). Five were accurate, and one had inadequate evidence. There were no inaccurate statements. An example of an accurate statement was, “Sharks lack a floatation bladder and must swim to avoid both sinking and suffocating.” The statement that lacked evidence in this category was, “Damaging the brain of a shark will kill it.” Though there were several reports of sharks being shot with rifles and subsequently dying (Skud 1962), none of these reports were specific in where the shark was shot and if the brain was damaged.

Table 4: The statements and research in the category other shark biology.

Statement	Citation (page in Benchley 1974)	Accuracy	Source
Sharks lack a floatation bladder and must swim to avoid both sinking and suffocating.	3	Yes	Budker 1971
Some sharks have eggs.	133	Yes	Budker 1971
No one has found an effective shark repellent.	117	Yes	Budker 1971
Blue sharks (<i>Prionace glauca</i>) live in the Atlantic and can reach 2.5 m.	233	Yes	Tucker 1958
Shooting a shark in the head with a rifle may not kill it.	233	Yes	Day and Fisher 1954
Damaging the brain of a shark will kill it.	280	Inadequate evidence	

There were seven statements in the category of other general biology (Table 5). Six were accurate and one had inadequate evidence. There were no inaccurate statements. One of the accurate statements was, “Phosphorescent plankton live in the Atlantic.” The statement that lacked adequate evidence was, “Tigers can acquire a taste for people.” It is unsurprising that no peer-reviewed sources have tested this concept.

Table 5: The statements and research in the category other general biology.

Statement	Citation (page in Benchley 1974)	Accuracy	Source
Phosphorescent plankton live in the Atlantic.	5	Yes	Biggley et al. 1969
Intertidal beach has holes made by sandworms.	23	Yes	Oglesby 1969
Tigers can acquire a taste for people.	32	Inadequate evidence	
Menhaden live off the shores of Connecticut.	92	Yes	Kroger and Guthrie 1972
Tarpon (<i>Megalops atlanticus</i>) are a popular sport fish in Florida.	236	Yes	Wade 1962
Porpoises are frequently caught as bycatch in tuna fisheries.	241	Yes	Perrin 1969
Bonitos (<i>Sarda sarda</i>) live in the Atlantic and can reach 2.3 kg.	245	Yes	Rivas 1951

There were 45 total statements (excluding anomalies); of these, 29 were accurate, six were inaccurate, and ten had inadequate evidence (Figure 1). There were ten anomalies (raising the total statements to 55) (Table 6, Figure 2).

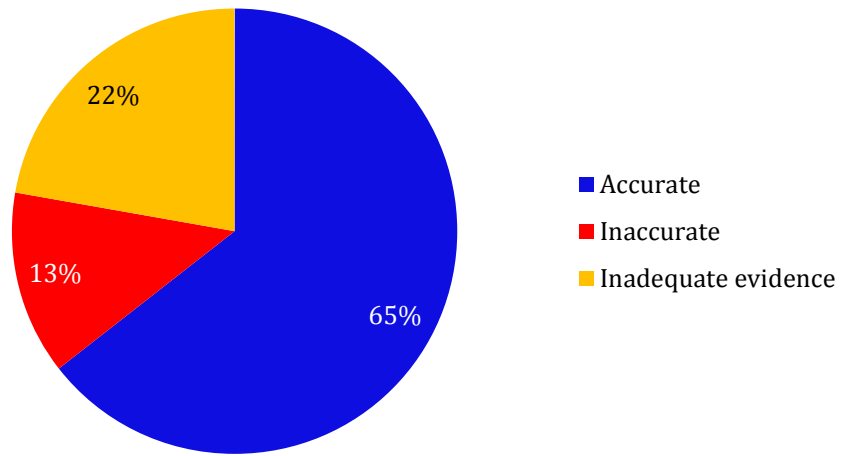


Figure 1: Percentage of accurate statements excluding anomalies.

Pie chart representing the percentage of accurate, inaccurate, and inadequate evidence statements without anomalous statements. There were 45 total statements; of these, 29 were accurate, six were inaccurate, and ten had inadequate evidence.

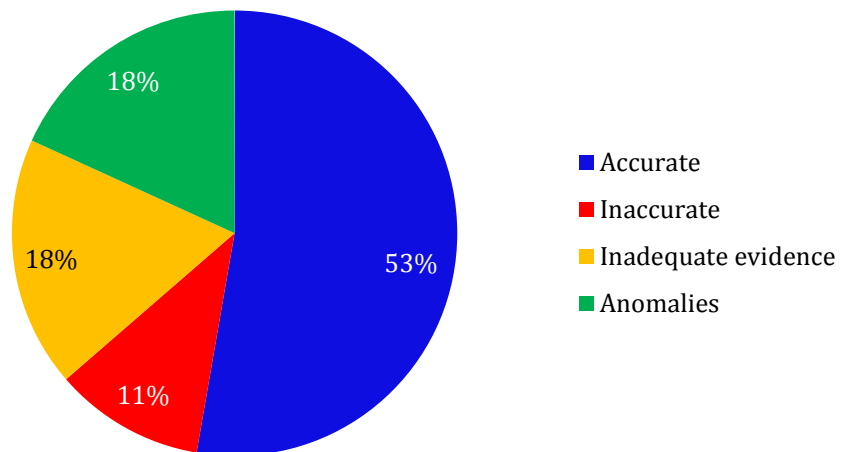


Figure 2: Percent of accurate statements including anomalies.

Pie chart representing the percentage of accurate, inaccurate, and inadequate evidence statements including anomalous statements. There were 55 total statements; of these, 29 were accurate, six were inaccurate, ten had inadequate evidence, and ten were anomalies.

Table 6: The statements in the category anomalies.

Statement	Citation (page in Benchley 1974)
It is unlikely the white shark would have stayed in the area for long.	37, 91, 180
The scientist believes it is surprising that there were two attacks within an hour.	63
It is rare for sharks to come so close to the beach.	64
It is weird that the all the attacks occur within one or two square miles of water and none have occurred up or down the coastline.	93
Contrary to its previous and future behavior, the shark is not compelled to attack the scientist's boat.	208
The scientist does not think the shark will attack the cage, but he is mistaken.	264
Contrary to the shark's previous behavior and the fisherman's assumptions, the shark would not come within fifty feet of the boat.	273
After attacking the scientist, the shark (with the dead body of the scientist in its mouth) breached and spent a few moments with its head above water for no biological reason.	288
The fisherman notes that it is unexpected that the shark chases their boat after being hit with two harpoons.	302
The shark sounds with three harpoons and attached barrels stuck into it, and swims in this state for several hours; the fisherman did not expect any fish to be that strong.	304

Discussion

I hypothesized that the science in *Jaws* would be, for the most part, inaccurate. My results do not support this hypothesis. Over half of the science referenced in the narrative, whether through character knowledge or character (including animal) behavior, was accurate. Further, of the six inaccurate statements, five were shown false by Randall (1973). This paper was released the year before *Jaws* was published, and so it is possible that Benchley was too far along in the writing and publishing process to

alter his use of the science accordingly. Thus, for the most part, the science that the novel claimed as accurate was, in fact, true.

The largest section of inaccurate statements was the anomalies, which the novel recognized as inaccurate or unlikely. Most of these statements were related to the shark's behavior, and so the novel excused their high improbability with the overarching concept that this shark's actions were out of the ordinary and unpredictable. The idea served the dual purpose of covering inaccurate statements and providing tension for the reader; because the novel regularly enforced the shark's mysterious behavior, it made it difficult to predict coming events, and thus made the audience eager to continue. However, the tension created by the anomaly of the shark was never resolved in the novel. It was regularly stated that the shark was acting abnormally, which led the audience to wonder why it was acting this way. Was it sick? Was it being drawn to the area for some reason? These questions helped provide tension throughout the book, but remained unanswered by the end.

Benchley could have also justified inaccurate science by using an unreliable source for scientific statements. Not all "scientific" observations in the narrative (such as the shark's length) were made by scientists, but were rather the observations of characters in the moment. For example, one character describes the shark as being the size of a station wagon immediately after seeing it attack and kill an old man (pg. 62). While the shark did have surprisingly similar dimensions to a station wagon, the man's observation was made while in shock and afraid. Because each character's viewpoint was not objective or quantitative, Benchley could have used their observations to frame inaccuracies as truth.

It should be noted that, for the purpose of this project, accurate means that I was able to find a source from 1974 or earlier that confirmed the scientific statement as a fact. One of my most useful sources was a book from 1971 by Paul Budker titled *The Life of Sharks*. I found so many parts of *Jaws* science in this book that I would not be surprised to learn that Benchley used this source himself while writing his novel. Though some statements confirmed by Budker have been shown as false by further research, and may have even been contradicted by some scientists at the time, the fact that *The Life of Sharks* was published as accurate means that anyone turning to it for research would believe the book's content.

Like many of the novels in earlier parts of this thesis, *Jaws* used the device of the Uninformed Character. This character was typically Sheriff Brody, and he was usually being informed by scientist Matt Hooper. There was a bitter rivalry between the two throughout the novel, and ultimately Hooper was eaten while Brody survived the shark's attacks (pg. 288). Benchley also painted Brody as a near-prophetic character much like he did Chase in *Creature*. There were some differences between the two cases; Brody's assumptions were based on logic and stemmed from the pressure on him as the sheriff, while the jumps in insight made by Chase were based on little to no evidence. Thus, Brody's aura of foreknowledge did not have the same negative effect of pulling the reader out of the story as Chase's foreknowledge did.

These elements combined to make Brody a powerful character in the novel. When he wanted to keep the beaches closed after the first shark attack, the mayor and city council convinced him that it was a bad decision (pg. 42). When he wanted to keep them closed several weeks after the subsequent attacks, Hooper explained the

unlikelihood that the shark was still around and the mayor overruled Brody and opened the beaches (pg. 68). Finally, once everyone agreed that the beaches needed to stay closed until the shark was killed, Brody got the final one-up on Hooper by surviving the shark's final attacks. Benchley's decision to elevate Brody to a position of higher authority than Hooper could be problematic in that it could push some readers into thinking that Brody's opinions of the shark were more correct than the scientific opinions. By the end, Brody considered the shark to be violent and intentionally malicious, with the specific desire to kill him and the ability to think through plans (pg. 270). Throughout the novel, Hooper maintained the position that the shark was only following its instincts and should not be villainized (pg. 94). Because he is killed by the shark in the end, the audience is more likely to agree with Brody's opinion on the shark, which is a viewpoint that biologists have been trying to undo for decades.

One aspect of this novel that I want to replicate in my writing is the clever use of vocabulary. Specifically, characters often refer to the great white as a fish rather than a shark (pg. 53, 238). Though both words can be accurately applied to sharks, fish is a more distant and less descriptive word. It also comes with fewer connotations. Even before *Jaws* was published, the word shark was nearly synonymous with vicious man-eater. Calling it a fish instead could help to remove the stigma; unfortunately, in this case, the benefit of calling it a fish was outweighed by Brody's villainization of the shark. Though it was not a wholly effective technique in *Jaws*, the use of terminology was clever and something I hope to bring to my writing.

Another element of *Jaws* worth considering, for both its usefulness and problems, is the way that Sheriff Brody was written as a complex character with

emotional depth. He was not written as a self-confident man who knows everything and thus must be heeded. Brody was insecure, and he showed weaknesses in both his actions and his thoughts. He threw up when he found the first victim (pg. 25) and worried about his wife cheating on him (pg. 132). Because he had such common thoughts and feelings on top of his very uncommon shark problem, it made him a more realistic character. Though not everyone in the audience can relate to a cheating wife, most people have likely felt jealous or self-conscious in their lives, and so giving Brody these characteristics gave the readers a way to relate to him and thus got the readers more involved in the story. The other side of that coin, though, is that there is a thin line between commiserating and whining. There were times in the novel that Brody crossed this line. While whining is also a very real experience for readers, it tends to make them dislike the character. Creating an unlikable character can be useful, especially when you want to kill a character and want the audience to feel satisfied with their death. Audiences do not want unlikable characters to succeed. When the unlikable character is also the protagonist, readers no longer want them to accomplish their goals and will feel distanced from the story. The trick is to write a character that can feel negatively about their problems without complaining about them ad nauseum, and this is the character that I will aim to write in my future work.

An element of this work that I do not want to incorporate in my writing is villainizing the animal antagonist. This is one of the serious issues with biology-based science fiction stories in general and this book specifically. It is also what makes writing animal antagonists challenging. An author's instinct will be to personify them, give them traits that allow the audience to dislike them, but the audience then takes

those traits and applies them generally to the entire species. It is much more difficult to write an innocent animal that also happens to be killing people, not because they are evil, but because they are hungry or sick or scared. This is the animal that I will strive to write into my work.

Finally, I was dissatisfied with the lack of intellectual resolution in this novel. Though readers are frequently told about the anomalous nature of the shark's behavior, that anomaly is never explained fully. The shark is instead given a mystical quality; some characters refer to it as an act of God (pg. 93, 180). It is possible that Benchley meant to provide this tone to the story in order to avoid answering the more scientific questions of why the shark behaved this way; another reason to leave the questions unanswered could have been to leave the reader with the fear of not knowing. If the latter was his goal, it falls back into the problem of villainizing all sharks. If we do not know why this shark behaved so oddly, then it is possible any other shark could behave in the same fashion. However, as a reader that was driven throughout the book to understand why the shark was an anomaly, I felt cheated when it died before we could understand why it behaved so abnormally. It is a feeling that I hope to avoid giving my audience in my writing.

Part 4

The fourth part of my thesis is the template for a science fiction story that I created with the previous three sections in mind. I then used this template to write my own short story in Part 5, though some aspects present in the template may be absent in the story and vice versa. Furthermore, this template should not be used as a tool into which authors can insert the appropriate information and easily create a good story. Though it can act as a guide, stories also require research and character development before they can achieve the label of well-written.

Beginning/Exposition

Most of the novels I analyzed used science heavily in their exposition. Here, the science is useful in establishing the setting of the story and lending validity to any science that comes later.

- The beginning of the story should establish a scientific anomaly or, in unrealistic stories, a setting in which science plays a significant role but that the reader does not yet understand. A desire to understand the unexplained parts of this science will drive the audience to continue reading. At this juncture, the writer must be careful to reveal enough information to keep the audience interested without making the science seem shallow or incomplete.
- The beginning should also establish multiple points of view in novel-length stories. These perspectives will be necessary to create the dramatic irony in the rising action.

- Though this section requires the author to educate their audience, simply giving them information is too passive and does not require the reader to engage. Instead, the author should use more subtle techniques for conveying knowledge to their readers, such as the Uninformed Character structure.

Middle/Rising Action

Science is useful in the rising action of a story because it creates tension while the reader tries to understand the mysteries of the scientific anomaly, or of the science-based setting. Like the exposition, the middle of the story continues to give the author opportunities to add credibility to their novel.

- For most stories, the author should use multiple points of view to create dramatic irony. Giving each character a more limited perspective than the reader creates tension as the reader waits for the character to understand.
- The rising action should also begin to structure two plots: an action-based plot and a scientific-based plot. The scientific-based plot should be driven by the audience's desire to understand a scientific mystery established in the exposition. The action-based plot can have many trajectories, but the significance and weight of the actions should have some basis in science.
- Adding science throughout the novel that is not directly related to the issue at hand is also a good technique that should be used by authors. Surrounding the bastion of plot science with a foundation of additional science will create a more sound and realistic structure for the story as a whole.
- If an author uses science that the audience may find questionable, they should provide an explanation for it. Curious readers may find the entire story less

believable if they do not trust the science, so authors should avoid distancing them from the story.

- Scientific processes are good sources of action that ground the reader in the setting and in individual scenes. Many parts of science include detailed processes, so authors should include these to add another layer of realism as well as to engage the reader in each scene.

End/Climax and Resolution

The end of the story, which should include a climax and resolution, involves science to a lesser extent than the rest of the story. It is important to properly resolve the science-based plot line, as well as any lingering scientific questions that the reader may have regarding the anomaly or any other mysteries the author may have introduced.

- The end of the story is a good time for the author to play with shifts in the point of view. By changing perspectives frequently near the climax, the author speeds up the scene and gives the reader a full understanding of what is happening, both of which are important near the end of science fiction stories.
- After the final climax, the rest of the story should be wrapped up in as few pages as possible. Now that the reader has had all of their questions answered, there is little left to compel them to read, and authors do not want to bore them and leave them with a bad impression of the story. Leaving one question, likely of less importance, to be answered in the falling action will provide the push to get readers through a quick explanation of what happens after.

Part 5

For the final part of my thesis, I wrote a short story using the template I outlined in Part 4. Creative writing is a long process, and though this story has gone through several drafts, it is still in revision.

Poison: An Original Short Story

Talia read the first five words of the letter, “We regret to inform you,” and dropped it onto her desk. She crossed to the work counter and hauled a robot the stone surface. She looked back, and couldn’t distinguish the rejected grant proposals from the rejected articles that lay strewn across her desk.

She focused her attention on the remote operated vehicle in front of her. She read the tag attached to its casing, then found the on switch and flipped it. The back left propeller whirred to life, but the right propeller remained motionless. She sighed, turned the machine off, and found the wrench that would fit the back panel screws.

The TV playing in the corner said, “In other news, there has been another death on the Canadian island of Regent.” Talia dropped the wrench and the screw fell to the floor. Cursing, she knelt and snatched up the screw before it could roll under a toolbox. She put it into a cardboard circle left over from a roll of masking tape and looked up in time to hear the anchor say, “... second death this week. Both are currently being blamed on a mysterious sea creature.”

Without taking her eyes from the TV, Talia reached for the stool. She fumbled with it for a moment before she pulled it close and slid onto it.

“More from Ryan Green, our correspondent in the field.” The screen switched to a young man in a professional-looking suit with a microphone. A beach spread out behind him.

“Thank you, Jackie,” the man said. “Though the waters surrounding Regent may look perfectly serene, something menacing is lurking in their depths. In the past week two vacationers of the local resort have died of mysterious injuries, likely caused by an unknown marine creature. Though government officials refused to comment, sources within the local hospital say that no one has been able to identify the creature, and they’re waiting for toxicology reports to learn more. Until the matter has been resolved, officials are urging beachgoers to avoid the water. Back to you, Jackie.”

The screen returned to the news anchor, and there was a pause before she said, “Thank you, Ryan. We’ll continue reporting on this story as it develops.” The next report began about a conspiracy involving the Secretary of State, but Talia ignored it. She ducked into the hallway and opened the door marked “Break Room.” A row of metal lockers lined one wall, and she opened hers and pulled out her cell phone. The screen alerted her to a missed call, and Talia sighed and let her shoulders fall. She fell into a chair and selected call back.

It rang twice before her call was answered. “Eva speaking.”

Talia smiled. “Hey, I got your call. What’s up? Is everyone okay?”

“You heard?”

“About the mysterious deaths?” Talia let her tone go spooky over the last two words. “Yeah.”

“Actually, that’s what I was calling about,” Eva said. “We were hoping you would come over and consult.”

Talia raised her eyebrows. “We?”

Eva’s voice warmed. “Mhm. Dr. Obi asked for you himself.”

Thinking about the row of repairs she had waiting for her, Talia sat back in her chair. “I don’t know…”

“At least come up for the weekend. The whole lab misses you, and I think we could really use your help on this one.” There was a pause, and Talia could hear Eva grinning. “Plus, the lab will cover your plane tickets.”

The lab looked no different than Talia remembered it. Water gurgled in the sea tables along one wall, and a counter of microscopes lined the other. A banner hung over one desk that read, “Welcome to the Obi Lab” in Jurassic Park font, and at that desk a dark-skinned man sat staring at a computer. He looked up when she entered, and she gave a little wave and dropped her duffel by the door.

“Ms. Fields,” he said, his voice lightly accented. He offered a hand, and she shook it.

“Dr. Obi. Long time, no see.” Obi’s smile dimmed, and his hand stilled before sliding out of hers.

“How is life on the West Coast?” he asked.

“Great,” she said. “Yeah, work is good. I’m an ROV tech, so I get to go on all the research cruises. It’s great.” Nodding, she rocked back on her heels and then forward.

They both turned toward the door when they heard footsteps running down the hallway. Eva skidded to a stop in the doorway, beaming.

“Welcome back,” she said, dragging Talia into a hug.

Talia melted into the contact for a few seconds, then pulled away. “As great as it is to be back,” she said, looking between Eva and Obi. “Why exactly do you need me?” Eva looked to the older professor, who sighed and looked at the floor. Talia’s heart rate sped up. “Does this thing have something to do with deep sea evolution?”

Obi met her eyes for a moment before looking away again. “It may.” His tone was hesitant. “There are some local ships that dredge the deep sea. I’ve consulted with colleagues from around the world, and no one else has any ideas, so I feel that the fishing ships are the most likely vector of introduction.”

Talia raised her eyebrows and twisted her lips up in a smirk. “So what you’re saying is I was right?”

Obi looked at her then, lips drawn into a thin line. “What I am saying is that we are desperate, and even ridiculous ideas should be considered feasible at times like this.”

Silence descended on the group, and only the gurgling of the sea tables could be heard. Eva was the one to break it. She cleared her throat and grabbed Talia’s duffel. “Okay, I’m going to go get my place set up while Dr. Obi gets you caught up. Have fun at the morgue!” With a wave, she left the other two alone.

When Obi and Talia arrived at the hospital morgue he said a few words to the medical examiner, and the woman eyed Talia the whole time. Once they were finished, she followed Obi over to Talia and stood with her arms crossed.

“You are here to help understand the animal attacks?” the ME asked.

“That’s the hope,” Talia said, grinning.

The medical examiner huffed, but turned and gestured for Talia to follow. They walked, with Obi trailing behind, towards a wall of small doors. The ME opened one, and Talia felt a chill as she slid out a table with a body on top. A sheet covered it from mid-chest to thigh, and Talia could see that the calf was badly abraded, the skin and tissue surrounding it swollen.

“There you go,” the woman said. “This is it.” She gestured to the leg, and Talia looked at her in surprise.

“This is the only wound?” she asked, scanning the rest of the body for any sign of injury.

“The only one we could find. The other victim was the same.” The ME turned away and walked to a different door, opening it and pulling out another body. On this corpse, the foot sported a similar injury. Otherwise, it appeared fine, abet dead.

“And these were somehow fatal?” Talia asked, and the medical examiner nodded.

“Poison, I think,” she said. “We found an unknown protein in the blood, but it does not match anything in our databases. And the second victim was treated with antivenom, but as you can see,” she gestured to the second body. “It didn’t help.”

Talia bent to look at the foot, and noticed that the flesh nearest the tears was shiny and white. “What makes you think this was a fish?” She looked up, and the ME turned and grabbed a glass jar from a counter. Its contents rattled.

“I took these out of the wounds,” the ME said. She passed the jar to Talia, and when she could see inside her eyes widened and brows rose.

“They look like shark teeth,” she said, confused. She unscrewed the top of the jar and removed one of the objects. “But they’re not.”

Obi was already shaking his head. “Denticles,” he said. “But I’ve never seen any this big.” The ME tilted her head, so he added, “Denticles are a shark’s scales.”

Talia frowned at the denticle for a moment more, then dropped it back into the jar. “I have no idea what these could have come from.” To the ME, she asked, “Do you know what their symptoms were, before death?”

The ME reached for a file and flipped through a few pages. “They complained of severe pain throughout the limb, but they were both unresponsive within an hour and were dead soon thereafter.”

“Which is consistent with a poisoning?” Talia didn’t mean for it to become a question, but her tone turned up at the end anyway. The ME raised her eyebrows but did not offer any further response.

“Great, thanks.” She turned to Obi to ask, “Can I get a copy of these files?” He nodded to the ME, and though she stood her ground for a moment, she soon snatched up several more folders and shuffled away.

Once they were alone, Obi asked, “Do you have any thoughts?”

Talia looked back at the second body, the one with the bloody foot, and shrugged. “None yet.” She pointed to the ragged flesh. “The nature of the wound bothers me. That much torn skin should have bled out--”

“All reports say it did,” Obi interrupted.

“Which should have cleansed the toxin from the bloodstream. It shouldn’t have killed them at all, and it definitely shouldn’t have killed them that quickly.” When the professor offered no response other than silence and a stony stare, she added, “Which I’m sure you already knew.”

She was saved from another silence by the ringing of Obi’s phone. He answered, and before he’d even properly hung up he was turning on his heels.

“Upstairs, now,” he called over his shoulder. “There has been another victim, already unconscious but not yet dead.”

When they got to the hospital, a nurse grudgingly allowed them into Emergency, and only after Obi insisted that Talia may be of some use to the patient. He sent Talia into the curtained room alone, opting to stay in the hallway himself.

She slipped past the hanging and immediately found herself shrinking into the nearest corner. The little cubicle was already full of people, shouting and crowding around the bed. A machine emitted shrill beeps, and their pace made Talia’s chest ache.

A woman in scrubs saw her and called, “Who are you?”

Talia took a deep breath and a step forward, squaring her shoulders. “I’m a scientist. I’m studying the animal that did this.” She nodded towards the man in the bed.

The doctor focused on her. “You know what it is?”

“Well, not yet. If I could see--” But the beeping stuttered, then returned in a single sustained tone. The doctor swore and turned all of her attention to her patient. She started chest compressions, and Talia stood forgotten and watched nurses wheel in a defibrillator. The doctor took the paddles and placed them on the man’s chest.

“Clear,” she yelled, and the man jerked under her hands. The monitor continued in its sustained note. She waited a few seconds, then yelled again. The defibrillator whined before it shocked the man again.

This time, the monitor quieted before letting out some short, stumbling beeps. Before the look of relief could settle onto the doctor’s face, though, it fell back into its single tone.

She followed her pattern of clear and shock several more times. None of them took, and at 16:27 Talia saw her first human death.

Talia stood over the newest body. She lifted the gauze that covered the wound (another leg abrasion) to see torn flesh beneath. Unlike the other injuries she’d seen, this was still covered in fresh blood, thick and bright red. The entire calf was swollen, and the bits of skin left around the cuts were shriveled and shiny white. Already dead. A powerful poison, then. Pebbled throughout the wound were embedded denticles.

“Can I take one of these?” She raised the gauze and pointed to one, and Obi shrugged.

“I’m sure it’s fine,” he muttered, and so with a pair of forceps she pulled one out and dropped it into a glass jar. It clinked against the bottom and left a bloody smear across the side.

“Are you done here?” he asked. With a final look at the dead man, Talia nodded.

At dinner that night, Talia glared at her notes, willing the pieces to fit together. Eva sat on the other side of the coffee table eating shrimp fettuccini while Talia’s plate cooled. Eventually, she closed her folder of notes and shoved it under the table.

“I need a break,” she mumbled, picking up her fork and stabbing at a shrimp. “My brain hurts.”

Eva nodded. “That’s fair.” Talia continued attacking her dinner, so Eva said, “Kind of an intense day.”

Talia nodded. “Honestly, I never thought I’d hear from Obi again.” She cut a glance up to Eva and added, “I was starting to wonder if I’d hear from you again.”

Eva blushed and focused on her dinner. “Yeah, sorry about that. I’ve just been so busy.”

Talia shook her head. “No, it’s okay, I get it. PhDs are hard, time consuming and all that.” She shrugged.

They ate quietly for a while until Eva smiled and said, “Well, you’re here now. And honestly, I think you might be right. Deep sea evolution was always totally plausible, I don’t care what Obi says.” She giggled. “Can you imagine the look on his face if he has to admit he was wrong?”

Talia grinned at the idea. “I’m looking forward to it.”

The next morning saw the two girls walking to the beach in rain pants, rubber boots, and tank tops, carrying a crate between the two of them. They met with Obi

there, and Talia asked, “You still have a skiff, right?” At Obi’s nod, she continued. “I want to take it out to the sandbar.”

He turned and started back. “This way, then. We’ll have to call our captain and wait for him to come in--”

“No need,” Talia said. “I’ve got my license.” At his look of surprise she added, “What? I had to diversify my interests after getting kicked out of grad school.”

Obi’s jaw tightened. “You were not kicked out. You left.”

Talia was already shaking her head. “Let’s just get the boat.”

It didn’t take them long to drive a truck with skiff attached down to the beach. They loaded Talia’s equipment (“What have you got in here, rocks?” “It’s an ROV I borrowed from work. Do you want to go diving before we see what’s down there?”), and she pushed them into thigh-deep water before hauling herself on board and starting the engine. They got past the sandbar, and Talia dropped the anchor. Her stomach wobbled a little with the boat, but she pushed the feeling away.

Together, the three of them pried the lid off the crate and pulled a little robot out of it. The name Flotsam was painted on the side of the dented yellow casing. It had several propellers on one end and head lamps on the other. Talia reached over the side of the boat and left it bobbing on the surface. She found the controls buried at the bottom of the box and withdrew them to begin piloting the robot. Eva huddled behind her to see the screen over her shoulder, but Obi stayed seated on the other end of the boat.

“We’re getting close to the bottom,” she said. “And that’s it... now. The sandbar’s going to be a bit east...” She adjusted some knobs and the bot turned

accordingly. “Let’s look around there.” And so they did. For half an hour they watched the feed from Flotsam, but other than some very ordinary and expected carp and some scuttling arthropods, they saw little. Certainly nothing that would have scraped up and poisoned three swimmers. Talia returned Flotsam to the surface and weighed the anchor. They tried their luck again a few hundred yards south, and again even further. Other than a false alarm involving a mangled tire, the searches were uneventful.

As she dropped the anchor at their fourth site, Talia said, “We’ll have to go back after this. Flotsam needs to recharge.” As she spoke, Talia absently piloted Flotsam toward the sandbar. She watched as a startled flounder swam off.

Another fish swam past, and Talia was surprised that she couldn’t identify it. Then her whole reason for being there caught up to her and she felt adrenaline speed up her heart and clench her stomach.

“Did you see that?” she asked quietly, though there was no need for her lowered volume. Eva nodded, her hand on the edge of the boat tightening, and Obi climbed across the middle row of seats to see the screen. She turned the ROV slowly, carefully, and breathed a sigh when the mystery fish came back into view.

Obi shook his head. “It’s a shark.” Talia turned to glare at him, but Eva kept her eyes on the screen as the fish turned to make another pass.

“No, look at its dorsal fin,” she said, pointing. “It’s all weird.”

“It’s some seaweed, or a hydroid,” Obi said, but as it swam closer, he trailed off. All three of them focused on the shark’s back, where the dorsal fin should have been. Instead, it had a growth that seemed to plateau. And as it swam beneath the camera, Talia could see that it was covered in large, sharp denticles.

She jerked her joystick around, and the camera jolted. When it steadied and focused, it was just in time for them to see the tail of the shark disappearing into the dim water beyond the headlamps.

“What the hell?” Eva muttered. Obi said nothing at all, but he looked pale.

Talia swallowed. “Guys, I think I know what it is.” Two pairs of eyes flashed to her, and she said, “This isn’t evolution. It’s a rediscovery.”

“*Stethacanthus*,” she said, leaning back so Obi and Eva could see the screen.

“Huh,” Eva said, studying the picture. “Yeah, I’d say that’s it.”

Both girls looked up at Obi, who was still staring at the computer. “Perhaps,” he said. “But how do you propose it has been poisoning people?”

Talia clicked through the search page into another article. She scrolled, and paused when some stained slides came into view. After reading the caption, she pointed. “With its brush. That’s its dorsal fin thing. No one knows what it did. Does. Whatever. The point is, that must be how it poisons people. Look,” She pointed to some irregularly shaped pockets on the slide. “People have assumed that these were for inflating the brush to scare predators. Which I’m sure it can also do. But these?” She pointed to the pockets nearer the surface. “There’s no reason these couldn’t be poison glands. Oh!” Her eyes grew wider, and she pushed away from the desk so fast that the chair started tipping backwards. Eva reached forward and caught it before it hit the floor, but Talia was already on the other side of the lab, digging through a bag.

“Where did it... hah!” She extracted a jar and held it at eye level.

“Look, look at this,” she said, crossing back and holding the jar where the other two could clearly see the bloodied denticle.

“See all that tissue on the flat side of the denticle?” she asked. Obi’s lips pulled into a thin line, and he gave a short nod. “It must be tissue from the poison gland. That’s why they die, even with all the bleeding. I don’t think the denticles are really what are killing people. They just open the skin so the poison can be introduced to the bloodstream from exposed gland tissue. Poison seeps from the tissue into the blood, and with a poison as strong as this, bam! You die.” She paused, her fingernail tapping a beat on the side of the jar.

Eva looked convinced, but Obi was shaking his head. “This is a stretch, even for you. One species of shark is poisonous, and the method of delivery is nothing like this.”

Talia gritted her teeth. “So the traits evolved independently. The dogfish only has a poisoned spine, but why evolve just a poisonous spine when you have this whole modified fin to work with?” She jabbed a finger at the picture still showing on the computer screen.

Obi raised his voice. “And how are you proposing people are receiving their injuries, exactly? Are they stepping on it?”

“Probably.” Talia increased her volume to match his. “That article said that they aren’t exactly fast. Their muscle attachments are all wrong. So stepping on them is entirely an option.”

Eva stepped forward, situating herself between Obi and Talia. She looked at Obi. “Okay, I know it seems weird, but let’s think about it. You’re the one who doesn’t believe in coincidences. What’s the likelihood that we rediscover an extinct species at

the same time that mysterious deaths are happening on the beaches, and the two are unrelated?”

Obi pinched the bridge of his nose, then sighed. “Fine, fine. Yes, you may be right. Either way, we need to catch this.”

He raised his eyes to Talia, and she smiled. “Great. Because I have a plan.”

Talia modified a basic crab pot to have larger openings. She cannibalized one of the cameras from Flotsam and attached it to the crab pot’s rope facing downwards. They would add their bait, drop the contraption by the sand bar, and wait.

The ocean was not as calm when they took the skiff out that afternoon. Talia had to work harder to push away her churning stomach, especially once they dropped anchor. The smell of their bag of bait didn’t help her efforts.

“Bag, please,” she said, reaching for it. Eva hooked a finger through one of the handles and held it out to her. She grabbed it and took a shallow breath to say, “Thanks.” Her fingers shook a little as they pulled at the knots holding the bag closed. After a second, she gave up, pulled the dive knife from her belt, and cut the bag open.

The mass inside was barely recognizable as a fish. It still had skin, but didn’t seem to have a general form. When she reached into the bag and grabbed a fin, it squished.

“Perfect,” she said, coughing and turning her face into her shoulder. She dropped it into the trap, then reached over the side and rinsed her hand in the water. She gestured the other two over and with their help hauled the trap into the water. While it

sank out of site, she rinsed the bag as well, balled it up, and threw it under one of the seats. Eva passed her the monitor, Talia booted it up, and they settled in to wait.

Various and sundry arthropods and worms took their share of the bait. Some fish visited too, but by midafternoon there was no sign of the shark. They talked on and off, but more often than not the trio sat in silence. Something occurred to Talia, though, and she glanced over to Obi.

“So what happens when we catch this thing?”

Obi and Eva both looked up. “What do you mean?” he said. “We will take it back to the institute and study it, and then we will return it to the wild.”

“Okay, yeah,” Talia said. “But what about me? I have a flight back to the West Coast tomorrow.”

“But you can’t go,” Eva cut in. “You’ll come back to the lab, right?” She looked at Obi.

“We will see,” he said, and Talia scoffed. His face hardened. “Contrary to our original beliefs, this phenomenon was not actually in your field.” He layered scorn onto the word *field*.

“But it’s proof that we don’t know what the hell is living in the deep sea! It could be integral to my research and--,”

“Guys!” Eva grabbed Talia’s arm. Her eyes were fixed on the control panel. Talia looked over, and on the screen saw a little shark, no more than three feet long, investigating their trap. They barely breathed as it swam around, trying to find the best approach to the meal inside. It passed the modified hole twice before it seemed to realize it was there, it pushed its head through until--

“It’s not going to fit,” Eva said, dread growing in her voice.

“It has to,” Talia said, but she could see Eva was right. Even with the brush on its back small and slumped, the shark could not push it through the hole. With a few sweeps of its tail, it tried to swim forward further and failed.

“We cannot let it escape.” Obi stood and started looking around the boat frantically. Talia just watched as the shark, realizing last that it couldn’t get into the trap, started trying to back out.

“Wait, wait,” Eva said, grabbing Obi so he would still. Every time the shark got its head back to the hole, it stopped...

“It’s stuck,” Talia said. “Its head denticles got stuck.” She reached across to the trap line. “We need to pull it up now.”

Eva reached over to help even as she said, voice loud in Talia’s ear, “What’s your plan when we get it up here?” Talia didn’t answer, because she didn’t know yet. Instead she pulled harder, and Obi grabbed the rope behind and pulled with her, and a few seconds later Eva yelled, “Sight!”

For the first time, Talia was seeing the shark without the aid of a camera. Its skin looked mottled, and the brush on its back looked raw and seeping.

“What now?” Eva called over the splashing of the shark as it struggled to free itself.

Obi yelled, “Get it on board, but don’t touch it.”

They each grabbed a side of the trap and hauled. The trap cleared the water, but the weight of the shark and its thrashing were more difficult to deal with. When a particularly large swell hit the boat just as the shark shook again, Eva lost her footing.

She tipped over and hit the water with a shriek, leaving the trap in Talia and Obi's hands. Talia hit her knees, straining to keep the trap above water. The shark had freed part of its head now, leaving denticles trapped in the netting. Talia's breathing hitched as she pulled again, barely feeling the weight anymore, until with a final heave she and Obi pulled the trap into the boat.

Talia fell backwards as the trap landed on her chest. She jumped up, shoving it away before the shark could touch her. In the water, Eva surfaced.

"Did you get it?" she yelled, using one hand to wipe water from her face.

"Almost, almost," Talia called back. Obi was still, looking at the creature with wide eyes as it finally thrashed itself free of the trap on the floor of the boat. "Rope," she yelled to him. "By your feet." He shook himself, then reached down and grabbed the rope. Together, they looped it around the shark's tail and pulled it into the cooler they'd brought.

"Got it," she said, hurrying over and offering a hand to Eva. "But we've got to get back fast or it's going to die."

The shark somehow looked bigger in the aquarium than it had in the ocean. Talia stood in front of the glass, watching the shark eat a dead fish. She heard someone come into the room and felt them looking over her shoulder. A glance to the side showed her it was Eva. She was grinning.

"So I talked to Obi," she said. "If you want your spot back in the lab, it's yours."

"Really." Talia returned her gaze to the shark. "What about applications and funding and me 'not being the right fit.'" She framed the last words in air quotes.

Eva laughed. “Please, technicalities. You helped with this, you get to study it. Even Obi thinks so.” She paused and then said, “So, you’ll come back?”

After heaving an overly-dramatic sigh, Talia said, “I guess I have to.” She watched the shark tear off the fish’s head and said, “There’s still a lot to learn.”²

² The references Enzor et al. 2011, Halstead and Halstead 1978, and Zangerl 1984 in the bibliography formed the basis of the research for this story.

Conclusion

Successful science fiction, as with any successful fiction story, must engage its readers. The stories I analyzed in this thesis found a variety of ways to accomplish this goal. Most of the novels used dramatic irony and two separate plots (one science-driven and one action-driven) to build the reader's interest. Each novel also had to explain its science without distracting the reader from the story, and most used the Uninformed Character structure to educate the readers.

Authors of science fiction have to create a careful balance between creativity and accuracy. Sometimes science has to be altered in order to fit the plot, but more often authors should change their plot to accurately follow the science. Even scientists who are experts in their field do not know everything, though; nearly all fields of science still have gray areas that have yet to be studied or fully understood. Writers can use these areas to their advantage and invent science to fill them. When authors begin manipulating science, though, they must make the choice of whether to clearly draw the line between science fiction and science fact or to blend fact and fiction without distinction. Both choices have their benefits and difficulties, though the former is likely more work. To distinguish between made-up science and scientific fact, writers have to use accurate science whenever possible, which requires considerable research. To avoid spreading public misinformation, though, I believe that the clear distinction is better.

Science fiction can be a useful vector for teaching the public about science. Authors of science fiction, especially realistic science fiction like *Jaws* and *The Andromeda Strain*, should consider the impact that any incorrect portrayal of science may have on their readers. The science itself, or the subjects of the science, could also

be negatively impacted by inaccurate depictions. This problem is especially relevant in stories in which the antagonist is an animal. These novels can easily cast a stigma across an entire species, and so authors should refrain from personifying and vilifying their animal antagonists. It should be the writer's responsibility (to their readers and to their topic science) to avoid the spread of misinformation. Thorough research and a distinct line between science fiction and science fact, authors can increase public knowledge while still delving into the creativity afforded by this genre.

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