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The Desert Burns Clean
**The Challenge of Conveying Accurate Science Through Embodied
Characters in Science Fiction**

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A thesis submitted in partial fulfilment of the requirements of Bath Spa
University for the degree of Doctor of Philosophy
School of Writing, Publishing, and the Humanities, Bath Spa University
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This study was approved by the Bath Spa University Ethics Panel on 17/05/2022. Should you have any concerns regarding ethical matters relating to this study, please contact the Research Support Office at Bath Spa University (researchsupportoffice@bathspa.ac.uk).

No new datasets were created during this study.

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Abstract

The Desert Burns Clean: The Challenge of Conveying Accurate Science Through Embodied Characters in Science Fiction.

This thesis is comprised of two parts: a novel, *The Desert Burns Clean*, and a contextualizing exegesis. Together, these two elements allow me to explore the challenge of accurately portraying the facts of a complex scientific reality while still accessing the truth of the human body experience. To achieve this, I utilize a variety of technical craft strategies in my fiction, while examining and reflecting upon them in my contextualizing exegesis in ways that I hope will be of use to other writers and critics.

Based on current scientific research, the novel is set in a future where optimal health—complete with long life—is available for those who can afford it through regular microbial inoculations begun at birth. In this fictional world, fertility rates have dropped, and epidemics have become common. Against this backdrop, I have created five protagonists who are diverse in terms of their genders as well as their cultural, educational, and racial backgrounds. They must work towards trusting each other to overcome the machinations of a wealthy and politically powerful owner of a fertility clinic who wants to exploit their bodies for her illicit research.

The contextual component of my thesis examines the strategies I use to incorporate accurate scientific information in the novel through the embodied experiences of my characters. My first strategy is that of worldbuilding. Here, the scientific information is not overtly present in the text but provides the “natural laws” of the world and how the characters will experience it. With worldbuilding, an accurate foundation of current science is laid from which all other aspects of story will be grounded. Secondly, I explore four forms of exposition through which I relate

scientific information overtly through my characters. Finally, I discuss the benefits, challenges, and limitations of conveying information through characters' body experiences.

We cannot escape the fact that information is processed in and through our bodies. Thus, fundamental to my argument and methodology is the premise that grounding information and knowledge in human body experience offers writers an important strategy for conveying complex scientific information accurately in a work of science fiction.

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The Desert Burns Clean

A Novel

[the creative section of the thesis on pages 7-424 has been removed from this digital version at the author's request]

Breeann Kyte Kirby

Contextualizing Exegesis

The Desert Burns Clean: The Challenge of Conveying Accurate Science Through Embodied Characters in Science Fiction

Chapter 1: Introduction

A body, situated.

A fact about myself has become clear while working on this thesis: I am equally a scientist and an artist. I love scientific study because it explores the mysteries of our world and suggests explanations—stories, if you will—for how these mysteries may be working. However, in my science writing¹ I discovered a serious challenge: how to portray accurately the facts of a complex scientific reality while still accessing the truth of the human bodily experience. I came to this PhD because I believe this can be done through the art of story.

Much of the research on the human microbiome—my scientific field—circles around microbes and their relationship to human health. The most accurate answer to the question of how does our microbiota make us healthy is that *it all depends and we still have a lot to learn.*² This answer is often unsatisfactory, which causes misunderstandings, misinterpretations, and “confusion about what science [... is]

¹ I have degrees in biochemistry and in molecular biology with an emphasis in virology and spent three years researching how hepatitis C virus communicates with its host cell as well as with HIV during co-infection. In 2010, I left bench research and joined the Rohwer laboratory as a literature researcher, particularly on the human microbiome and the virus-host dynamics in it. I still work with the Rohwer lab. I also have a popular science book forthcoming from The MIT Press on the human microbiome and viruses’ roles in human health.

² When explaining the implications of emerging, paradigm-shifting science such as the human microbiome, the goals of accuracy and clarity are harder to achieve than one might think. Often one scientific research paper’s conclusions about the human microbiome can be called into question a few weeks later by another’s. The truth about the human body is that we are ecosystems as diverse from each other as a rainforest in the Amazon is from a rainforest in the American Pacific Northwest. Further, if humans who are fairly evolutionarily static are so diverse from each other, microbes with their seemingly devil-may-care attitude toward genome change are exponentially so. Thus, defining a good or bad microbe is as slippery as defining the genre of science fiction. Whether a microbe is helpful or harmful varies depending on its context in its ecological community and what element is being examined. For example, *P. gingivalis*, the microbe that causes gingivitis, can only do so when in community with certain other microbes. Without that community, *P. gingivalis* is benign (Hajishengallis).

capable of doing [and] leads to polarized emotional reactions” in the general public (Nagy 746). This is the tension in scientific discourse (as seen in vivid relief during the SARS-CoV2 pandemic): in an emerging field, it’s almost impossible to make an accurate scientific statement as a simple takeaway for a human who is living right now with a specific lived body experience. Our ancestors attributed many things we now know to be microbial influences to spirits and gods. This inaccurate explanation got at the truth of their lived experiences within their bodies. Humans want a clear and engaging story about our bodies, not complicated explanations and cautions. Often the explanations and qualifiers that make good scientific research divorce the information from our physical experiences.

Thus, the impetus for my novel was born out of my scientific research on the human microbiome, particularly the interplay between our resident viruses and our resident bacteria, and this research provides the information scaffolding for the fictional world discussed in Chapter 2 of this contextualizing piece.

In the course of writing my novel, *The Desert Burns Clean*, and thinking about it as research practice, I’ve learned that as an artist, I can’t set aside the other defining aspect of my character. And these two strands—artist and scientist—not only affect how I engage with the world as a human in a physical body—experiencing life through my senses—but they also have braided themselves throughout my work and inform the entirety of my thesis: the novel and this contextualizing analysis. Just as I cannot separate these aspects of my personality, I cannot separate these two parts of my work. It’s my assumption going forward that even if the readers of this contextualizing piece are not scientists, they are or soon will be, familiar with my novel and will use it to understand the following pages.

As a creative writer, I recognize that I want my novel primarily to delight and entertain.³ Just as in my scientific writing, *it all depends, and we still have a lot to learn* does not lend to a gripping fictional narrative. And this is the challenge writers who include science in their fiction face: we must make decisions about the information included in stories. *The Desert Burns Clean* is an attempt to navigate this tension of portraying accurate scientific information while simultaneously creating a narrative that delights and feels true to our lived experiences in our human bodies.

Personally, I delight in narratives that seem to bridge the chasm between knowledge and body experience by offering different (albeit often nonscientific) ways of seeing and being in the world, from the weird fiction of China Miéville and Paolo Bacigalupi to the richly descriptive non-fiction of Rebecca Solnit.⁴ The key attraction for me with these writers is not just their ability to tell a compelling story but also to create a sensory experience.⁵ This conveying of the human being as a body in the physical world seems to be one of the keys to engaging readers, and I have tried to emulate this element in my own fiction (as well as nonfiction) writing.

As a writer of science fiction and a molecular biologist, I am drawn to possibility. The more I've learned about the weird wonder of the microbial world, the more struck I am by how hard it is to maintain strict boundaries between organisms. This knowledge questions my (and culture's) ideas of what it means to be human, and concepts of who or what is other. Particularly in my scientific writing on microbial

³ To clarify, "delight" and "entertainment" are not merely feel-good and trivial goals. Delight can be found in something well crafted, in mastering a new art, in accomplishing a task that was difficult (such as writing this thesis). Thus, delight is that sense of pleasure when things work well. Similarly, entertainment is not merely a check-out from life but a moment of engagement with something where ex-stasis may be achieved: the person is transported out of the boundaries of their current paradigm into a new one.

⁴ All of these authors have a vast body of work. Particularly what has delighted and entertained me was Miéville's *Perdido Street Station*, *The City & The City*, and *Looking for Jake*; Bacigalupi's *The Windup Girl*; and Solnit's *A Field Guide to Getting Lost*.

⁵ At least for me as a reader.

ecology and viral dynamics, connecting the reader to how these practically invisible organisms actually affect her body is challenging, since scientific accuracy requires a level of disengagement from the visceral (pun intended). There are work-arounds to this challenge, of course, such as the use of metaphor and tropes. For example, in the Isaac Prologue, Isaac uses story as a metaphor when speaking about his work in genesplice: “individual cell types—yours, mine, a microbe’s, a goat’s—and viruses tell their biological stories and [...] those stories create a whole narrative that makes an organism or a colony or even an entire ecosystem” (DBC 361).⁶ However, metaphorical strategies are ultimately asking the reader to let one experience stand in for the other. It isn’t quite the same as a feeling it in your own body. So, additionally, I pair Isaac’s explanation with Raiah’s connection to how she experiences movement in her body when she dances. I will go into more detail about my attempt to pair metaphor with physical experience in Chapter 4.

I love science fiction—stories about the human condition that overtly attempt to engage in the scientific practice of elucidating the mysteries of life. Often science fiction writers call their stories *thought experiments* that explore avenues of possibility—*if* such and such scenario were to happen, then.... It’s this *if* that feels linked to the mystery being explored in scientific research and offers much of the same pleasure in the reading, as well as the writing, of science fiction.

Thus, in setting up a future world in the narrative context of my novel, *The Desert Burns Clean*, I described what I see now and what may be *if* certain paths are chosen in technology, science, and human culture in the light of climate change,

⁶ When referencing the novel which is part of this thesis, I will use the citation convention of (DBC page#).

political upheaval, and manipulation of the human body. Like author Margaret Atwood, I am interested in exploring “our own planet in a future [...] carefully say[ing] *a* future rather than *the* future because the future is an unknown: from the moment *now*, an infinite number of roads lead away to ‘the future,’ each heading in a different direction” (Atwood 5; author’s emphasis). I explore in *The Desert Burns Clean* what our future might look like in the face of climate change and manipulation of the human ecosystem.

But I didn’t begin writing this novel thinking about the parallels between making art and undertaking scientific research. Rather, I thought I wanted to write this novel because I was frustrated with science fiction writers getting the science wrong in their work, and I wanted to see if I could do it better.

Hubris, yes. But scientists are nothing if not confident.

However, I found that the issue isn’t about getting science wrong or right but about what the goals of the story are. There isn’t a simple dichotomy between “good” and “bad” science in science fiction. In the course of my writing and research, I exposed my own binary thinking. Revising how I thought of science fiction was my first iteration of the experiment that is my novel: I learned that my initial avenue of pursuit was not nuanced enough and that I needed to refine my research practice by clarifying my goals.

One thing that quickly became apparent to me as I began this clarification was that I had no idea what science fiction as a genre actually was. I have long been a reader of science fiction—able to discern what entertained and delighted me—but until this project I had not approached the genre as a critic who was engaged in academic discourse. I possessed many preconceived notions about science fiction, but the more I read and spoke to both critics and writers, the more I realized my notions were

incorrect. Worse, I began to suspect that my thoughts were outdated, making my research focus about accurate science in science fiction irrelevant to contemporary practice. As an educator, I see this often with my students: they believe that they have discovered some new avenue of thought but, in reality, what they have discovered is an abandoned discourse that is merely new to them. It doesn't negate the work of personal discovery that they have done, but it does limit what they can add to the larger conversation. To put this in scientific terms: if I were to spend my time using an electron microscope to reveal the double helix of DNA, I would have done the work and learned a lot, but it doesn't benefit the scientific community—we already know the structure of DNA. To demonstrate my expertise, I need to add something new to the academic discourse around my field.⁷ In order to contribute new knowledge, I need to understand the knowledges⁸ that already exist.

What is science fiction, anyway?

At first, it seemed easy to define science fiction: it's fiction with a scientific component. However, during the course of my research and practice, I soon learned that attempting to define science fiction is like falling down a rabbit hole. Better not try. I needed some understanding of what aspects of science fiction were important to me before I began writing a work I wanted to label as “science fiction.” While fully

⁷ As Lyle Skain's writes in “Creative Practice as Research: Discourse on Methodology,” the creation of new knowledge is essential to advanced study:

Doctoral candidates should not expect to receive a research degree merely for creating an artwork and then reflecting upon it, as that does not meet the criterion of offering new knowledge to the domain; it might be new knowledge to the candidate, but it is also applicable only to the candidate, rather than the domain as a whole. We as the field serving as gatekeepers to our creative writing/arts domain must stand by this criterion, and expect no less of creative research than we do of “traditional” (read: familiar) arts and humanities research.

⁸ I am intentionally using knowledges in the plural here to indicate that knowledge isn't static or homogenous. Different cultures may access and codify knowledge differently. Therefore, I do not want to assume in my speech that knowledge must conform to the western idea of it even though I am from that paradigm.

addressing this question is beyond the scope of this contextual piece, I will relate what understanding I gained in my pursuit of answers as they specifically influenced my practice and the novel.

Science fiction is a literature of speculation and possibilities. It examines the what-is-now and plays with what-could-be (Russ). As such, science fiction as a literary genre opens up a diverse array of storytelling that is unified under the speculative umbrella of human possibility, but resists consensus as to exactly what makes one story science fiction and another story not.

This resistance to a codified definition is both a problem and a blessing. Since science fiction became widely popularized in the 1920s, writers and readers have tried to refine and define sub-genres in an attempt to better classify which avenue of possibility a science fiction story travels. From hard science fiction and biopunk to slipstream and science-in-fiction (and many, many more), these labels reveal a tension in how to approach the genre that isn't easily resolved. Even 100 years later, with many science fiction memes incorporated into our cultural narratives and realities, there's an element of engaging with cliché in the public image of science fiction, a genre which is ostensibly concerned with scientific accuracy and logic but also has historically and sometimes problematically been associated with fantastical space travel, laser guns, and women in pointy bras (Hartwell). Beyond these stereotypes, conveying accurate science (or pseudoscience with authority) has often been employed as a gatekeeping strategy to keep certain writers from being considered "serious" science fiction writers (Larbalestier).

Thus, many writers (many being women or Black Indigenous People of Color (BIPOC)) of the literature of speculation and possibilities resist the label of science fiction. For example, Nigerian-American author Nnedi Okorafor calls her science

fiction work that is centered on African (mostly Nigerian) culture “Africanfuturism,”⁹ and Canadian author Margaret Atwood calls her work “speculative fiction” rather than science fiction.

In the case of Atwood, this labeling appears to be more semantics than an actual codifying of genre. When called out by Ursula K. Le Guin for this nomenclature as a way to “protect [Atwood’s] novels from being relegated to a genre still shunned by hidebound readers, reviewers and prize-awards [because s]he doesn't want the literary bigots to shove her into the literary ghetto” (Le Guin “Margaret Atwood”), Atwood asserted that what Le Guin “means by ‘science fiction’ is what I mean by ‘speculative fiction.’ [...] When it comes to genres, the borders are increasingly undefended, and things slip back and forth across them with insouciance” (Atwood, *Other Worlds* 7). And so, Atwood’s and Le Guin’s quibbling about the definition of science fiction brings us back to the unsexy scientific answer to the question of what is science fiction: *it all depends*.

And this is the crux of the matter: if I were to define what I mean by science fiction based on literary history, the genre—like microbes in the human body—just won’t remain static. In examining genre theory in general, Daniel Chandler affirms that genre is “a theoretical minefield” where “one theorist’s *genre* may be another’s *sub-genre* or even *super-genre* (and indeed what is *technique*, *style*, *mode*, *formula*, or

⁹ In Okorafor’s own words from her [blog](#):

Africanfuturism is similar to “Afrofuturism” in the way that blacks on the continent and in the Black Diaspora are all connected by blood, spirit, history and future. The difference is that Africanfuturism is specifically and more directly rooted in African culture, history, mythology and point-of-view as it then branches into the Black Diaspora, and it does not privilege or center the West.

Africanfuturism is concerned with visions of the future, is interested in technology, leaves the earth, skews optimistic, is centered on and predominantly written by people of African descent (black people) and it is rooted first and foremost in Africa. It's less concerned with "what could have been" and more concerned with "what is and can/will be." It acknowledges, grapples with and carries “what has been.”

thematic grouping to one may be treated as *genre* by another)” (Chandlers 2, 1; author’s emphasis).

Perhaps to a greater extent than other genres, science fiction has proven to be difficult to define because it has become a commonplace lens through which to view our increasingly technological world. As the SARS CoV-2 pandemic has emphasized, “science fiction [sf] has moved from being a niche genre [...] to a widely shared cultural vernacular for describing the twenty-first [century]. In many ways, sf is no longer a specialized genre, but now the dominant way to analyze a world in which our technology changes faster than we do” (Vint, *Science Fiction* 55). Science fiction then has a role in the articulation of the dominant paradigm but also is dismissed as frivolous fiction that perpetuates cliché.

There’s a special tension when a dominant paradigm is simultaneously viewed as cliché. We can see this tension creep into literary discourse in the ways authors and critics now define literature with scientific elements as something other than science fiction. For example, critic Paul Hamann-Rose discusses the “science novel” as something separate from science fiction, and author Ian McEwan describes his *Machines Like Me*, which deals with the science of artificial intelligence, as a “fiction about science.” Both seem to ignore (or perhaps reject) the rich (albeit sometimes problematic) history of science fiction. McEwan acts as if his work is breaking new literary ground, claiming “there could be an opening of a mental space for novelists to explore this future. [...] Not in terms of traveling at 10 times the speed of light in anti-gravity boots, but in actually looking at human dilemmas” (qtd. in Ditum). To which many professed writers of science fiction in any sense of the genre (including myself) would protest, “that’s exactly what we’ve been doing.” However, despite being erroneous, McEwan’s flippant reference to anti-gravity boots and faster-than-light

travel discloses the continuing gap between the genre's potential integration into culture and the clichéd ideas of it that dominated the early- and mid-20th century—and even reflects a little of my own misconceptions when I first came to this research project.

So, what was I to do? Defining the genre of science fiction would by itself be a PhD thesis, and I had a novel to write. Thus, I made a decision to inform my practice with a particular corner of science fiction and to lay aside all the others. Specifically, I am concerned with science fiction that addresses biological sciences, particularly the biological science of the human body that describes how the human body engages in its physical environment and culture. While I prefer to focus on science fiction extrapolated from current biological research and set on our Earth, at times, I have used texts that are more far-reaching in their speculations and settings, as long as the focus is on biology.¹⁰

In her introduction to *The Left Hand of Darkness*, Ursula K. Le Guin calls science fiction a “thought experiment” that “is not predictive; [rather] it is descriptive.” As a thought experiment, science fiction explores the implications of an idea, scenario, or technology. While thought experiments can be primarily concerned with information, many science fiction stories engage in thought experiments as a way to explore the human condition.¹¹ Exploring a thought experiment relies on conveying information invisibly through worldbuilding and overtly in exposition. Worldbuilding mixes familiar with new (and sometimes strange) information and supports overt exposition

¹⁰ I have one notable exception with Cixin Liu's *Three Body Problem*.

¹¹ Andy Weir's *The Martian* is an example of an informational thought experiment: can someone survive on Mars. Le Guin's *The Dispossessed* is an example of a thought experiment that explores the human condition: how do the structures of capitalism and anarchy play out if they could have an entire world for each.

so that we can extrapolate worlds from the possibilities of our own, making them mirrors of sorts to the reality we have now.

In exploring the roles of thought experiments in science fiction, I wondered if this could be a way to access a lived human experience, since there would be a connection to our own lived-in world (albeit one that is through the looking glass of the future or fantastical). Like Le Guin, I don't want to predict the future (in the case of the "botched," I hope not) but to examine the human condition now—I want to "tell all the truth but tell it slant" as Emily Dickinson would say.

In my research and practice, linking the playful aspect of thought experiments to our reality proved a fruitful avenue for me to pursue. For example, with the effect of climate change causing more intense natural disasters, I wondered how the U.S. federal government would be able to continue to provide financial relief to affected citizens. I asked what would happen if the federal government stopped providing disaster response, leaving it to the individual states. Perhaps the state governments would also not be able to handle this financial burden and would collapse. What entity would then be in a place to take over? My playful answer would be various university systems. Thus, in my novel's world, the federal government controls only national parks and national defense while universities run various city-states.

With this kind of play, I was able to release the pressure of needing to make a wholly accurate future prediction. Instead, I could focus on the cultural now, the current scientific knowledge, and play with what-might-be given our present moment. Groundbreaking cyberpunk writer William Gibson asserts that the "least important thing about science fiction [...] is its predictive capacity" (Dayal). If one considers science fiction as merely a prediction of the possibilities of science—which by its nature is to accurately investigate and elucidate the workings of the universe—then

we run into the problem of science fiction being limited, especially when the scientific research that an extrapolated world is built upon is still emerging, such as the research I do on the human microbiome.

Rather, science fiction's extrapolation of a world has to get at a "something," as Gibson calls it, that "relatively few people [... are] paying attention to" yet is an important part of the human condition. It is that "something" Gibson accesses in his *Neuromancer* or Mary Shelley in *Frankenstein* or Octavia Butler in *The Parable of the Sower*. It isn't an accurate prediction of the facts of the future reality but it is accurate in the truth of the human experience.

That "something" is the core of the thought experiment. In a speech, author Octavia Butler said that she sees three types of science fiction stories: "The what-if category; the if-only category; and the if-this-goes-on category" (Butler, "TRANSCRIPT: 'Devil Girl from Mars'"). Thus, the exploration of a thought experiment looks at what-is right now and postulates what-may-be. Orienting my thinking along this path enabled me to align my creative practice with my scientific inclinations because I could stay grounded in the present scientific knowledge while postulating a future.

Critic Matt Webb says, science fiction "is a scientific investigation, and the lab bench is the book. It's a thought experiment in narrative form. [...] Sci-fi uses the power and constraint of story to find its way through. And by doing that, discoveries are made." The very act of writing science fiction, then, is an act of research—exploring a hypothesis based on data from the here-and-now world. What I hoped to do with my novel is provide a foundational grounding in accurate science of our now and use that as the framework to describe how the human condition (humans in bodies) might continue in the future.

Thus, approaching my practice as engaging in a thought experiment allows me to explore not only how does one relate accurate scientific knowledge about the known world but also what makes us embodied humans within this world.

Though the scope of my research question limits itself to conveying biological science accurately, it's important to note the sociocultural and political implications of a focus on human bodies—particularly those bodies that can gestate and give birth. In the novel, I have developed themes of reproduction and the future of humanity, exploitation of bodies as commodities, and gendered control over the rights and ability to reproduce or choose otherwise.

With these themes, my novel joins a vast sub-genre of science fiction that deals with human reproduction and reproductive rights. This sub-genre—which includes, amongst many others, such well-known works as Louise Erdrich's *Future Home of the Living God*, Octavia Butler's *Dawn*, P.D. James' *Children of Men*, and Joanne Ramos' *The Farm* as well as such key writers as science fiction scholar Sherryl Vint—is important and long-established part of science fiction's wider examination of oppressive structural systems. Further, fiction writers such as Ursula K. Le Guin, Kazuo Ishiguro, and Margaret Atwood not only examine the portrayal of science in fiction but also overtly challenge white-supremist, cis-hetero-patriarchy. As critic Kaye Mitchell claims, feminist theory has “repeatedly returned to the ‘matter’ of the female body, seeing this as the ‘battleground’ where struggles against patriarchy are fought” (113). I would add that “female body” is too limiting a term when considering who patriarchal structures target with regards to reproductive autonomy. In extrapolating “a future,” I was not inured to events surrounding human rights and bodies that current power structures class as female (or not female). From the 2022 United States Supreme Court ruling on reversing *Roe v. Wade* to the continuing

protests in Iran (at the time of this writing, March 2023), gender identity and reproduction are tied to human rights and ideas of whose bodies deserve those rights.

While I believe that these themes in my novel are important and deserve further examination, for the purposes of this research question, I set them aside for future work that I hope to inspire others to do as well as continue myself.

Is exploring accurate science in science fiction even relevant now?

Finding a helpful definition to me of what is science fiction and exploring thought experiments contributed to my development as a writer and thinker, but I still needed to be clear that this research was actually relevant. As I read further into the critical conversation around accurate science in compelling narrative, I found little that critically addressed this issue after the late 20th Century—a conclusion I confirmed in an interview with science fiction scholar Sherryl Vint.¹²

Across disciplines there is a critical conversation about using science fiction as a teaching tool. Further, there is a large body of research on the use of science fiction to teach STEM subjects;¹³ I myself have used Michael Crichton's *Jurassic Park* and the movie *GATTICA* as ways to introduce DNA and genetics to my biology students. In *Teaching Science Fiction*, educators Andy Sawyer and Peter Wright

note how easily science fiction can jump disciplinary divides: “Its hybrid nature and the way it emphasizes connections and contrasts between cultures, disciplines and ways of thinking, make it a fitting

¹² Of note is Vint's latest book *Biopolitical Futures in Twenty-First Century Speculative Fiction* which does address how the scientific depiction of humans in science fiction can shape humanity. However, Vint does not address whether or not the texts she analyzed got the science right.

¹³ See Burgess, Seitz, and Boaz.

subject for any syllabus committed to assisting the social and intellectual transformation of its students” (18). (qtd. in Burgess 65)

Further, educator Cynthia Boaz asserts that using science fiction and fantasy allows students to engage with fraught cultural issues, “engag[ing] them in the subject matter and [helping] them retain ideas longer afterward” (Boaz 244). Educators are seeing science fiction as valuable for not only teaching scientific concepts but also addressing complex social issues.

However, in terms of critical writing about science fiction, it seemed I had entered an abandoned conversation about why science fiction writers should care about accurate science in their work. Vint assured me that the conversation is not dead amongst actual practitioners of the craft—in our conversation, she referenced writers like Ted Chiang and Peter Watts who include extra information at the end of their novels explaining the science behind their narrative. These examples indicate that this topic is still of great interest to writers even if it is not being addressed by current science fiction critics.

I would assert that accurate science in our stories has value for our larger world beyond that of legitimizing a text as science fiction. Kristen Koopman writes, “Here’s the vicious truth about how science fiction works: It reaches more people than will ever read any scientist’s papers” (“To Boldly Know”). I believe that it is worthwhile to renew this critical conversation especially in light of how often we engage with scientific research in our cultural institutions, in social interactions, and around our ideas of what it means to be human. As Vint claims, “it matters that fiction responds to ongoing scientific change, to show how posthuman framings can be the grounds for more ethical worlds for humans and more-than-humans alike” (*New Biopolitical* 19). As a woman in science and a writer of science fiction, my voice may be able to add a

critical element to the body of science fiction writing. Vint told me that she knows of only one other (woman) writer—Joan Slonczewski—who is writing stories about human/microbe symbiosis, my own area of expertise and fictional inspiration (Interview).

As I alluded above in my reference to science as a form of legitimization, the history of science fiction has been fraught with misogyny and racism. One historical example is the scandal that occurred when famed “male” science fiction writer James Tiptree, Jr. was revealed to be the woman Alice Sheldon (Phillips). Science fiction writer S.B. Divya explains that the best-known authors of science fiction are often white men because they tend to fit our cultural ideas of what authoritative voices sound like:

We live in the year 2021, and yet we persist in associating certain jobs—and certain types of stories—with specific groups of people. [...] Why do we struggle to break free of these narratives and associations? Because we have so few counterexamples that are publicized. It’s not that they don’t exist, but they do not permeate our popular consciousness.

Koopman concurs, claiming further that the authority of the scientific (male) voice in science fiction has often silenced or undermined other diverse voices (*Who Speaks Truth* 68). I agree with Koopman’s postulation that in the constraint of a problematic tradition, fruitful modes of envisioning agency for a human body and the expression of valuable perspectives have been lost to conversations about science fiction.

I would add to her argument that it is important for contemporary writers to find a way into scientific discourse (rather than eschewing it) and to claim the scientific paradigm for all humans not merely the often-found white male. As Vint

speculates, “had the genre always embraced such pluralistic voices, we might have a very different set of images that spring to mind when we hear the term *science fiction*” (*Science Fiction* 16)— images that would tap into the power possessed by a literature with possibilities for accessing the spectrum of human embodied experiences. I hope that my novel will contribute to this opening of how science can be incorporated in science fiction in this way and that my explorations of craft technique will be helpful to future artists.

*CHAPTER 2: Framing the Structure***Foundation and framing of worldbuilding.**

I believe that being committed to a foundation of accurate science in my worldbuilding was essential to communicating scientific information and creating embodied characters that feel true to human experience. Speculative fiction (including science fiction) creates elaborate and complicated worlds that are simultaneously similar and utterly foreign to the world we actually inhabit. As such, it's important that the writer establishes the worldbuilding foundation and framing of their fictional world. As a creative writer, I believe that anything is possible in fiction—humans can shift their sex based on hormonal cues (Ursula K. Le Guin's *The Left Hand of Darkness*), humans can mutate into other organisms (Kirsten Imani Kasai's *Ice Song*), and a proton can be unfolded to code a destructive element for humanity (Cixin Liu's *The Three Body Problem*), to name only three—but the possibility must be true to the fictional world. Worldbuilding gives a story its veracity.

Just as when building a house one needs a good foundation and solid framing to create a stable structure, worldbuilding is hidden supporting information that determines all the seen craft aspects of the text. Many seminal writers of science fiction from Isaac Asimov to Hugo Gernsback have emphasized the necessity for realistic worldbuilding to support sometimes complex scientific concepts or fantastical settings of a speculative story. Writer Joanna Russ says that though “science fiction is [...] about human concerns, [...] science fiction must not offend against what is known. Only in areas where nothing is known—or knowledge is uncertain—is it permissible to just ‘Make it up.’ (Even then what is made up must be systematic, plausible, rigorously logical, and must avoid offending against what is known to be known.)” Worldbuilding is an important goal of science fiction because direct transmission of

knowledge itself (see next chapter) must be done in a fictional world full of sensory details and cause/effect moments that feel true to its narrative.

Though the foundation and framing of a house are invisible once the structure is completed, a person living in the house can infer their presence and even feel if these elements are “off” or wrong. I think of foundation and framing as the physical and biological limitations of the world inside the story, similar to how gravity functions in ours. Or as a scientist would say, the foundation and framing of worldbuilding are the natural laws that govern what is possible within that specific story.

Worldbuilding encompasses many of a story’s craft elements, for example its setting and characterization, but is for the most part invisible—as natural laws often are. The information behind worldbuilding may not be overtly mentioned in the story. Just as we aren’t continually conscious of gravity nor do we regularly think of the scientific explanations about it, still gravity greatly affects our expectations and sensory experience with the world—when we toss the house keys to our child, when we enjoy a glass of good wine, when we make love to our partners, when we stumble down that last unexpected step.

For example, we can see how various natural laws dictate how characters experience the world in Margaret Atwood’s and Joan Slonczewski’s novels. The technology for space travel is possible in both Atwood’s *Maddaddam* Trilogy and Slonczewski’s *Elysium Cycle*. In Atwood’s work, which is set in a near-future version of our own world and obeys our own natural laws of physics and biology, her protagonists would only be able to survive on another planet where arsenic was the primary molecule if they were genetically engineered as an embryo to do so. In Slonczewski’s books, characters (both human and non-human) often emigrate as adults to toxic planets because they can (relatively) quickly manipulate bodily makeup

to accommodate diverse habitats.¹⁴ These authors have established different natural laws for their worlds which then dictate their characters' embodied experiences.

Ultimately, worldbuilding lets us experience a fictional world as if real through our senses. As Janet Burroway points out in *Writing Fiction: A Guide to the Narrative Craft*, stories “occur in time and through time; people move in space and through space” as well as engaging with other biological elements that are essential to bodies; thus, characters—like all organisms—“must have an atmosphere because without it [they] will be unable to breathe” (171, 172). My goal with laying a strong foundation and solid framing of worldbuilding is that there would be veracity in the scientific world within my novel which would contribute to a trueness of lived experience in our sensory bodies. In my worldbuilding, my characters should be able to breathe.

Worldbuilding also transmits vital information about the fictional world—information the reader needs in order to fully suspend disbelief even if the most fantastical and strange things happen. However, this information transmission is not overt. Rather it is inferred by the reader over the course of the story. However, just because the information isn't overtly stated, it doesn't mean that it isn't there. My research question explores how to include accurate science in science fiction while also creating a story with a true lived-body experience for my characters; therefore, I decided I needed to firmly ground the novel in current scientific knowledge that set the invisible natural laws of my world.

In my practice, I found that there was a twofold aspect to incorporating information through worldbuilding. First, I wanted to incorporate information in my

¹⁴ Slonczewski does allow that younger people are changed easier than adults, but adults still can be altered in some ways.

worldbuilding through prior knowledge my readers would bring to the text. Of course, I could not be certain of all the things my readers might know. But I felt fairly confident that I would be able to rely on shared body experiences by depicting moments with literary realism which could be layered with additional strange or fantastical elements.

Secondly, I spent a lot of time researching foundational scientific concepts that would shape the natural laws of my world. For every idea I had about a future technology or possibility, I determined what sort of current scientific thought would inform it. I will explain in detail three examples of my background research with regards to my scientific focus on the microbiome in the following pages, but I'll provide a quick example now. Currently, the American West is experiencing what scientists call a mega-drought (Williams et al.). Though many climate predictions depict it becoming dryer and more desert-like, some research indicates that this region—particularly California—may actually become wetter (Allen and Luptowitz). Further, the city of Reno in Nevada, though high desert, is part of an extensive basin fed by the Truckee River which comes down from the snowpack in the Sierra Nevada Mountains in California (Tashev). This geographical situation and climate predictions, led me to speculate that future Reno in my novel is actually a water-rich city despite drought in other areas. At the western entrance to Reno, Maeve freely fills her Camelback with water from the communal fountain (DBC 20). We learn later that this fountain is a testament to the city's wealth as water is expensive and highly regulated (DBC 20).

Familiar and strange.

Worldbuilding requires transmission of information about the “rules” of the world without direct exposition. Because the information behind worldbuilding is inferred, it is important that the reader does have something to orient herself as she is figuring out the natural laws of the world. One strategy is to mix familiar—or realist—elements with the fantastical and strange so that the reader can overlay her own sets of knowledges from her lived experience. The writer assumes that the reader will possess some knowledge of the familiar elements and then builds on these to help the reader grasp the unfamiliar aspects—complex and strange worlds become nevertheless accessible because they contain familiar elements.

For example, I use familial relationships like Veronica’s loss of their brother in my novel to lay a foundation of familiarity on which I then build the perhaps more unfamiliar aspects such as Veronica’s being a surrogate for clones. They (Veronica’s pronouns are they/them) are still grieving the loss of Vince, their twin brother, who died while he was serving in the military overseas in “one of the many identical wars” that also killed Raiah’s mother (14). Veronica wonders why his death doesn’t feel real—they were twins after all—and often thinks about how Vince helped to smooth the relationship between Veronica and their mother. Familial dynamics of loss are not universal; however, my hope is that the general sense of Veronica’s feelings about their blood relationships will be something all readers can relate to as well.

A skilled composition of familiar and strange creates a world that feels true so that the reader agrees to suspend disbelief no matter how many impossible-for-our-world things may occur in the text. It requires a combination of sensory cues and information about the nature of the world (in science fiction this will often be scientific

information—biology, physics, chemistry, etc.). Writers are advised to establish the natural laws of their story clearly and early in the text (Burroway). However, the worldbuilding that builds on the familiar to introduce the new often occurs over the course of a novel or series, with the natural laws emerging and evolving as the reader's understanding of the world grows. In other words, as the reader becomes more familiar with the world, the author can then increase the strangeness. In the previous space travel example, both Atwood and Slonczewski use continuous worldbuilding to establish the natural laws as a process over the course of their text(s) so that the reader is willing to accept what happens to the characters.

For her readers, microbiologist and science fiction writer Joan Slonczewski combines elements familiar with the strange and new. Slonczewski has integrated her microbial research into her novels by creating the world Prokaryon (*The Children's Star*).¹⁵ In this world, sentient microbes are the dominating species. However, because they operate on different time and size scales, neither the microbes nor the emigrating humans recognize each other as sentient. Slonczewski sets her readers up for this meeting of intelligences by accessing the reader's familiarity with the science fiction trope of human—and human-like—people who are searching for intelligent life on a planet that has life forms with a very different physiological makeup.

She also uses the conventions of infection and immune response that we are familiar with to stage the first contact between the sentient microbes and their most recent hosts: humans. In the excerpt below, politician Verid uses current knowledge of host/pathogen dynamics to query how humans and the sentient microbes might become collaborators.

¹⁵ The planet's name is a play on the word *prokaryote* which describes an organism whose cells lack a nucleus. Bacteria and Archaea are prokaryotes. Organisms whose cells have a nucleus, like humans, are eukaryotes.

Verid asked, “What becomes of a pathogen when its host dies? What if the microzoöds *need* us alive? Even among ordinary pathogens, the most successful eventually mutate to coexist with the host—millions on our skin, and billions in our intestine. What of an intelligent pathogen who remembers its history and values its host?” (*The Children Star* 153)

Using current research on and understanding of microbial evolution and host/microbe symbiosis, Slonczewski ends her second novel in the *Elysium Cycle*, *The Children Star*, with some humans choosing to act as host “worlds” for populations of sentient microbes.¹⁶

Atwood, another master at complex and engaging worldbuilding, uses a realist style and familiarity with literary tropes and motifs to develop her world and its natural laws. She sets her readers up for what seems to be a simple dystopian novel,¹⁷ then complicates expectations of what that sort of novel entails. At the beginning of *Oryx*

¹⁶ In the subsequent book, *Brain Plague*, she continues to cultivate the sentient microbe worldbuilding of the previous novel, allowing her to increase nuance in the human/microbe relationship as well as expand information about other cultures that comprise her complex universe. In *Brain Plague*, the protagonist, Chrys, at first does not understand about sentient microbes and chooses naïvely to become a host world because she thinks it is nano-technology that will enhance her art. Using a novice whose journey and increasing knowledge parallels that of the reader’s is a common practice in fiction. Through growing relationships with her new symbionts and with other people who act as host worlds, Chrys (as well as the reader) learns the rules about hosting sentient microbes. In addition, if the reader has read the previous novels, then she is privilege to more information than Chrys and can provide even greater nuance to the worldbuilding. It is this layering of familiar and new that provides fecundity to Slonczewski’s worldbuilding.

¹⁷ Of note with my novel, many readers interpreted my world as dystopian. The dominant cultural conversation classifies science fiction that imagines humanity’s future into binary categories: broadly, dystopian or utopian. Certainly, the trend at the moment is to read novels such as Paolo Bacigalupi’s *The Water Knife* and Kim Stanley Robinson’s *The Wild Shore*—two writers who situate their novels in an American West affected by various climate and political realities, just as I do—as dystopian stories of a world ruined by human actions. However, despite their dire settings, my close examination of the works I have mentioned above will demonstrate that these imagined futures are more nuanced than the conversation has so far allowed. Where we choose to focus often dictates our ideas of dystopian or utopian. Does the current (September 2022) situation in Iran mean we live in a dystopia? Certainly, if we had a story set only in that context, it would be read that way. In this same month, I spent a week with supportive women as we cooked together, walked together, shared our emotional states, and wrote together. Utopian? There have been utopian stories with similar settings.

and Crake, where apparently only one natural human has survived a disaster, Jimmy/Snowman lives a life of scavenging subsistence. As the trilogy progresses, the novel evolves from a tale about a lone survivor in a deadly and ruined world to a saga that comprises multiple humans and transgenic animals forging a community together. Atwood reveals this information over the course of the three novels rather than laying it out in early chapters. In doing so, she links her fictional world to the reader's familiar one to support the elements that differ from our current reality.

Seeming to rely on the reader's familiarity with dystopian motifs, the first chapter of *Oryx and Crake* opens with Jimmy-as-Snowman waking up in what appears to be a tropical beach setting. However, the reader learns in the second paragraph that this is not a happy moment nor is Snowman marooned somewhere in a world as we know it. Rather, as the "deadly glow" of the sun and the "assorted rubble" suggests, something cataclysmic has happened:

On the eastern horizon there's a greyish haze, lit now with a rosy, deadly glow. Strange how that colour still seems tender. The offshore towers stand out in dark silhouette against it, rising improbably out of the pink and pale blue of the lagoon. The shrieks of the birds that nest out there and the distant ocean grinding against the ersatz reefs of rusted car parts and jumbled bricks and assorted rubble sound almost like holiday traffic. (3)

Already, the reader may be formulating familiar scenarios that have left Snowman in this situation. Snowman's world may be destroyed, but it's a world similar to ours with cars, holiday traffic, "tins of motor oil, caustic solvents, plastic bottles of bleach. Booby traps" that may be from Snowman's past but are our present (7). With this establishment of familiarity in her setting, we are able to relate to Snowman's physical

experience of isolation and deprivation, which is similar to what we've experienced in our reality. Simultaneously, the readers are primed to accept later that in this future, humans have built upon our current technology of genetic manipulation of embryos (Cyranoski and Reardon) and have apparently moved past the ethical debate to produce the strange Crakers—designer humans with scented skin and perfect bodies who turn blue for sex and purr to heal wounds. By incrementally adding the strange to the familiar, Atwood and Slonczewski are able to meet and then challenge expectations, building upon foundations of the familiar to make their worlds feel true.

Science fiction writers describe our world but through a looking glass, so that we, the readers, can make some assumptions but also form new expectations for what is possible. Sherryl Vint states that ideas of possibility which evolve over the course of reading a story offer a paradigm shift, providing a desired payoff for readers, and claims that this evolving worldview is one that the science in science fiction readily enables (Interview). This figuring out the natural laws of the world is one of the aspects that delight and entertain science fiction readers. In my own worldbuilding, I explored the tension between what I believe will be the reader's potential expectations and what might be surprising as I play with realist and familiar elements as a way to introduce the strange and new.

To evaluate the effectiveness of my worldbuilding, I depended partly on reader feedback from my PhD seminar group. For example, in an early draft, I began the novel with the Maeve Prologue so that the first sentence of the book was "Maeve didn't believe in zombies, but the noise Kenneth's corpse seemed to be making in the tiny house was causing her to reconsider" (DBC 258). In this scene, teenage Maeve is huddled under the trailer she used to share with her family in a desert commune. Her

parents are dead in the trailer above her as are all the other adults in the commune, each in their own trailers. Thus, Maeve, now alone, sleeps outside, surrounded by the dead. The noise she hears is actually a man—the stranger—who is fleeing the same epidemic that killed Maeve’s community. He has stumbled upon their circle of trailers by accident as he drove through the Southern California desert. Through the course of the Prologue, it becomes clear that the stranger isn’t a zombie, but a fantasy of Maeve’s because of the emotional stress she is under.

However, because this was the first sentence of my novel, my readers attached weight to it, making strong assumptions about the natural laws of my world that allowed zombies. Their critiques of this beginning were that I didn’t do enough to make the stranger a realistic zombie nor explain how the epidemic could create zombies. With this feedback, I realized that if I wanted to keep the zombie line (and I did), I needed to shift this Prologue to a later place in the novel, after my readers had become clear that zombies do not exist in this world and that Maeve is just subject to an active imagination.

In my attempt to layer the familiar with the new, I inadvertently tapped into a familiar trope of zombie fiction which then set up my reader’s expectations about what types of new elements would feel true to the world. This was not my intention. The revision of moving the Prologue to later in the novel and being clearer in my language that the zombies were only in Maeve’s imagination allowed me to use the familiar trope of a zombie fantasy to establish ways of thinking about Maeve’s sense of loneliness, after which I could then introduce perhaps unfamiliar elements like microbial role in decomposition after death (DBC 269).

Here, the structure of my novel was helpful. I have divided my novel into five sections of five chapters and a prologue to each. I envisioned this partitioning of the

prologues in the novel to function like cells do in a multicellular organism: each is its own entity, but information and worldbuilding is shared across sections, providing nuance and depth as the story progresses. Thus, moving Maeve's Prologue to later, allowed me to include realist and familiar elements before to prepare my reader for her fantasy about zombies—and eventually her mental state.

Hidden information.

Because the types of science fiction novels I considered for this project are centered around biological and ecological concepts, there is a lot of background information that is needed to inform the world the characters live in. I place my novel in a possible future that extrapolates from the physical limitations of our current world, particularly in aspects of climate change and microbial ecology. These elements serve as the foundation of my world's natural laws, but also allow me to build on them across the course of the novel in a way, I hope, that feels true to the embodied experience of my characters.

While the scientific foundation and framing of my world are extensive, I will offer three examples of the invisible components of my worldbuilding. With all of these, I rely on the reader's familiarity with an aspect of the science, a shared physical experience, and/or a literary trope or motif working with the new and strange.

Microbial dynamics are predictive technology for the climate

As researchers today continue their examination of the microbial and viral world, they are gaining insight into how larger ecological processes both influence—and are influenced by—microbes. In *The Desert Burns Clean* the effects of climate change have continued along the predicted trends of the 2020s with sea levels rising and

hurricanes growing in strength (NOAA; Kossin, et al.). This has impacted coastal communities, particularly those along the American Gulf Coast, in ways that are the subject of familiar conversations today.

We meet Raiah in the first Prologue on a sampling trip with her father, Joe, to collect microbes. The air is humid and close because a hurricane is only a few days from landfall. Her father intends to use the microbial samples to determine the imminent hurricane intensity so that their community can best prepare for evacuation and damage control. In this scene, I merge how I've experienced the familiar sensation of a looming hurricane with a theoretical advancement of science.

To situate the reader, I first access the familiar physical experience of humidity and storm energy: Raiah's "dark curly hair was simultaneously heavy with humidity and charged by the electricity of the incoming hurricane still miles from landfall. [...] Big storms were commonplace on the Gulf Coast" (DBC 8,10). After I have established a familiar experience (or at least a relatable one) with the commonly scientific thought that storms are getting more and more severe due to climate change, I then weave in a concept unfamiliar to the reader: "a way to predict storm severity using the shift and ebb of viral and microbial interactomes and populations in the Gulf waters and along the Atlantic coast"—a microbial marker for hurricane intensity (DBC 10).

Connecting microbes to the speed of hurricane winds may seem farfetched, but current research supports this extrapolation. In a paper that came out of the Rohwer Laboratory, researchers looked at the viral genomes of twins—one who was malnourished and the other who wasn't. In the Discussion, the authors note that the viral composition in the malnourished twin's gut ecosystem shifted even before the twin showed signs of malnourishment, suggesting that resident viruses could be some

sort of bellwether for disease (Reyes, et al.). Granted, this previous study is about the human body, and the Gulf of Mexico is not an equivalent entity. But in another study from the Wegley Kelly Laboratory that looks at microbial community abundance in coral reefs in the day and the night, some microbial species greatly expand their populations at certain times of day (see figure 1). The researchers concluded that microbes are as sensitive to light as they are to other environmental changes such as pH (Kelly, et al.). So, I took these two ideas, amongst others, and extrapolated to a future where humans could figure out a microbial signature for storm intensity.

This actual research isn't mentioned in my novel. Rather, it is the worldbuilding foundation and framing—invisible to the reader—from which the visible moments derive their veracity.

This possible use of microbes from weather signals to human health informs much of the backdrop of my novel and the physical experiences of my characters. Like Slonczewski with her research, I see my fiction through the lens of my research on the human microbiome, which focuses on the powerful ways that microbes shape human physiology. Unlike Slonczewski's fictional world the host/microbe relationship in my novel extrapolates from the relationship scientists are currently elucidating between microbes and our environment.

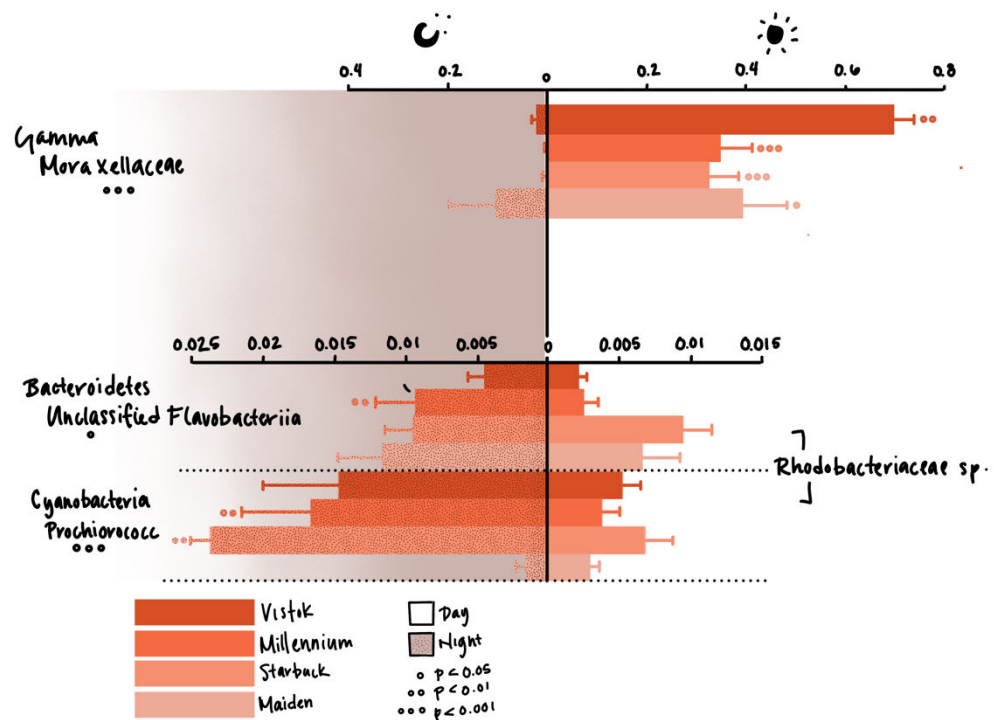


Figure 1: Illustration by Leah Pantéa depicting the population dynamics between day and night microbial communities. Original figure from [Diel population and functional synchrony of microbial communities on coral reefs](#)

Microbial inoculation is used for optimal health

Another potentially strange aspect of the world in *The Desert Burns Clean* is that my characters know and accept that microbial manipulation exerts a selective pressure on host phenotype—microbes can give your cells instructions that affect your appearance and behavior. I extrapolate this unfamiliar concept from more familiar ones about how our genes affect phenotype that transcend ethnicity and race, for example the genes for having red hair. My character Samuel August, a politically influential scientist, comes from a background of privilege that enabled his parents to ensure that he received a carefully chosen inoculation of microbes to colonize his gut at birth as part of a study to see if using a specific community of microbes could make people healthier.

In envisioning the effect microbes might have on human morphology, I drew on insights from studies on the human genome on how phenotype is expressed as well as research that suggests our microbial symbionts are responsible for our health, weight, disease state, mental state and much more. Then drawing on the biological principle of selection,¹⁸ I created a group of humans who have been inoculated at birth with an optimal microbial community. This selection of optimal microbes provides the individuals with better health, but they also express an unintended universal phenotype, “slight and pale, long in limb and torso” (DBC 146). This physical appearance is not linked to changes in their human DNA but to signals that the microbes are giving to their human cells about how that DNA is expressed.

I overtly introduce inoculants in my novel through Samuel August, a participant in the first inoculation study. He was

inoculated with custom microbiota immediately after birth and reinoculated on the vaccine schedule thereafter, he didn’t manifest the surprising lack of pigmentation more recent generations of inoculants exhibited as microbial selection and host colonization techniques became more refined. Still, he was tall—taller than both his parents—and had some of the bird-bone grace that characterized inoculants and

¹⁸ Selection actually occurs on the external behavioral and physical manifestations of an organism which may or may not have a correlation to its DNA. One of the misconceptions is that selection improves organisms over time. But this is not true. Selection puts pressure on organisms to best fit the current environment without a value and sometimes with unintended consequences. In a simple example, pretend that red is your favorite color, and you are in a store that sells magnets. So, as you walk along carrying your basket, you choose only red magnets. You don’t think about their polarities or their basic composition; rather, you are only selecting magnets that have external manifestations of red that you prefer. Eventually the contents of your basket will reflect your choice of red as well as other unintended consequences because you didn’t select for other factors like size or polarity. If you think a bit, you can probably come up with examples of selection across biology. And you’ll note, whether you think of moth camouflage, finch beaks, or giraffe necks, that each example results in a physical trait that helps the animal better survive in a specific environment. While changes to our DNA source texts can be random, our physical manifestations are not: they must make sense to the outside world; selection makes sure they do.

likely the long lifespan to boot. He definitely didn't feel 67, but then again who did. (DBC 34)

As I've established in the introduction, current research points to the microbiome being a key element in human health. And as early as 2016, scientific research has supported that newborn infants could (and possibly should) be intentionally inoculated with beneficial microbes (Dominguez-Bello, et al.). Further, in September 2022, scientists from Stanford revealed that they have successfully created a custom microbiome that could successfully be established and maintained in the guts of mice (Cheng, et al.). The consensus in the scientific community is that microbes have the potential to dramatically affect the biology of their hosts (Rogers, et al.; Fujimoto, et al.) and that the period immediately after birth is an important window within which inoculation should occur. Hence why Jes has Sebastien wipe down the newborn clones with her vaginal swab—she is attempting to inoculate these infants with her microbiome (DBC 404).

Today, we can see microbes' biological effects on us in ways that we like and expect, such as curing a life-threatening *C. difficile* infection (Baunwall, et al.), and in ways we don't, such as weight gain (Alang and Kelly) or a deadly attack on lung tissue (Güemes, et al.). Knowing that, I speculated that an inoculation for microbes that we think are healthy might have an unexpected and universal phenotypic side effect on height and skin pigmentation, much like having red hair (see figure 2).

[image removed from the digital version of the thesis]

Figure 2. A creative collage of very different humans all expressing the red-haired phenotype taken from a Google Images search.

The phenotype for red hair is linked to variations in the MC1R gene. However, it isn't a simple causal relationship. Research indicates that other genetic factors—and I speculate that in the future we'll find microbial factors as well—contribute to this phenotype (Morgan, et al.). All this research and more (which is included in my bibliography) serve as the invisible scientific foundation and framing of an unintended universal phenotype that is mediated by microbial signaling in people who were inoculated with an optimal microbiome for health.

Thus, in my novel, Samuel and future generations who experience microbial inoculations at birth will express a phenotype of height, skin pigmentation, health, long life, and eye color that transcends race and ethnicity. Inoculation phenotype is an indicator of wealth as only those who can afford the necessary regular re-inoculations can ensure optimal health for their children.

Human biological research and manipulation of genetics is illegal

What about those who can't afford it but also want their children to be healthy? This question leads to my last example of worldbuilding: human biological research and manipulation of genetics is highly illegal and punishable by forfeiting your rights as a human. More precisely, the punishment is to become a human research subject, which is what happens to Maeve, one of the five main characters in my novel.

In foregrounding microbes as the future of optimal health, I made a decision to avoid speculation on the future of human genetic manipulation. Thus, playing on reader familiarity with the trope that manipulation of the human body is harmful and problematic,¹⁹ I made genetic manipulation and use of any human biological material in research unethical and illegal. However, I didn't want to ignore the fact that we do have the technology now to perform genetic engineering. It wasn't consistent with my worldbuilding (or scientifically accurate) to pretend that the technology doesn't exist. Instead, my future speculation posits that the problematic effects on society from genetic manipulation and research on human biological material would be so great that microbial manipulation would be seen as the "safer" and legal route. Rather than focusing on the human genome (human DNA), the future in *The Desert Burns Clean* values the metagenome—all the genes whether human, microbial, or viral that comprise the human—and are perfecting switching in and out, in modular fashion, viral and microbial genetic components. We see this in how Samuel's experimental generation

benefited from a measured approach to metagenomic manipulation—targeted genesplices, viral therapy, and idealized microbiota—before the general public began unwittingly mass experimenting in an attempt

¹⁹ Arguably, the first writer to establish this trope is Mary Shelley in *Frankenstein*.

to access the golden age of health promised by the media. The FDA didn't regulate metagenomic manipulation—inoculations, genesplice, in vivo epigenetic modification—until faced with the horrific botched outcomes of home-splicing and unregulated fecal microbial transplants. (DBC 35)

Currently, we can splice genes into cells because of the elucidation of CRISPR- Cas9 technology (derived from viruses and microbes). In 2018, Chinese scientists claimed a successful edit of the CCR5 gene in embryos which provides immunity to HIV but also could increase cognitive ability. These scientists also claimed two children had been born with this successful edit (Regalado “EXCLUSIVE: Chinese Scientists Are Creating CRISPR Babies”). The scientific and public outcry at this act was great, and He Jiankui (the lead scientist) was eventually fired from his university and sentenced to prison for his unethical behavior (Cyranoski and Reardon). Despite the consensus that altering an embryo's genes is unethical behavior, the Chinese research has opened up the possibility of successful genetic manipulation which could one day promise to eradicate horrible genetic diseases.

But why stop there? If we can genetically engineer the absence of disease, couldn't we positively engineer for desired traits? If providing immunity to HIV has a side effect of increased intelligence, wouldn't most parents want both for their children? In 2017, a panel of the US National Academy of Sciences met to discuss what guidelines should be set for this very thing (Regalado “U.S. Panel Endorses Designer Babies to Avoid Serious Disease”). But as technology advances, complex scientific research can actually be done in private homes. In our present, there is a Do-It-Yourself or “DIY” science movement which has created eager anticipation of what citizen science can do (Ravindran). The DIY science movement also inspires

fear, particularly of the possibilities for bio-terrorism as DIY scientists become more adept at biological manipulation.²⁰

As Vint pointed out in our conversation, many readers today are for the most part familiar with these advances and the controversy accompanying them. I was able to then layer in the new idea that such research may become illegal in the future, but not before there have been tragic outcomes from trying. Environmentalist Bill McKibben writes,

Should we so choose, we could exercise our reason to do what no other animal can do: we could limit ourselves voluntarily. [...] What a towering achievement that would be. [...] Such restraint—not genetic engineering or planetary management—is the real challenge, the hard thing. Of course, we can splice genes. But can we *not* splice genes?” (1128; McKibben’s emphasis).

The familiar cultural trope is that humans lack this restraint (perhaps started with Shelley’s *Frankenstein*). But I believe that humans enact restrictions when faced with dire consequences. So, I have included in my work a population of humans unkindly called “the botched.” This group is the product of DIY scientific experimentation by desperate parents who attempted to access optimal health with the tools available to them. The pressure to do this, despite the risks, comes from the desire for the health, strength and longevity of someone like Samuel, but a lack of the substantial funds, resources, and knowledge to ensure its safety and efficacy.²¹

This worldbuilding supports the overt information present in the Samuel Prologue of Section 2. At the beginning of this chapter, Janice—Samuel’s mentor and

²⁰ Richard Powers’ *Orfeo* looks at the social consequences of DIY science (as art) and a paranoid government.

²¹ The DIY trend of fecal microbiota transplants is an example of what people will do in the pursuit of health. (see “The Power of Poop”: <https://thepowerofpoop.com/>)

head of a DIY bio lab—is talking to two such desperate parents. Later in that chapter, Samuel is at a government dinner attempting to influence the draft of a bill that will make scientific research on human biological samples illegal. He knows that this type of bill will not only stymie the advancement of science but create problematic black markets. However, Samuel’s dinner companions are focused on the tragedies of a generation of botched children. These politicians are not interested in the nuances of scientific research. In my novel, the senator from Wyoming brings up an instance of the botched: “Only last week, they found a child who was a victim of its parents. The poor thing didn’t have eyes—not that it was missing eyes, but its face didn’t even have the place for eyes—just skin stretched across. And something else neurological was wrong too” (DBC 83-84). The chapter ends with an act of bioterrorism: the President of the United States targeted by a designer virus. This act thwarts Samuel’s attempts to salvage scientific access to human biologicals, so he tries to find loopholes that ultimately have unintended negative consequences.

Samuel helps co-author the Human Biological Research Bill which makes research on human biological materials illegal, yet does create one important loophole: if someone has been convicted of trafficking in human biologicals, then that person forfeits their rights as a human and becomes a test subject. As he predicted, a black market arises as researchers attempt to get access to human samples any way they can. Of importance, the industrial-prison complex is able to provide biological-trafficking convicts to laboratories. When Samuel is meeting Maeve, his former student turned trafficker in human biologicals, at Silver Peak Brewery, he notes a news report stating that “a person convicted of biological trafficking was incarcerated at the University of Texas Teaching Hospital. There the convict will serve their sentence as a research subject for the betterment of mankind” (DBC 34). This foundation and framing is

essential to the rest of the novel's story as Isaac Pickwell, Samuel's longtime friend and one-time colleague, for all his ideals, performs genetic manipulations on embryos and adult humans while Maeve traffics in this black market and has sold samples to Samuel. Later Maeve is caught and sentenced to become a research subject herself—owned by Jes Comstock, the ruthless owner of a fertility clinic and Isaac's boss. Under the cover of the fertility clinic, Jes funds illicit research in her quest to live forever with Isaac serving as her head scientist.

Discussion.

The three examples of scientific research that formed the worldbuilding foundation and framing of my novel illustrate just how much background knowledge went into creating the natural laws of *The Desert Burns Clean*. While much of what underlies that creation is hidden, I have tried to demonstrate the research that went into establishing the world of *The Desert Burns Clean* as well as how I attempted to link the familiar (the physical sensations of a hurricane approaching and the desire of parents to have the best for their children) with the strange and new (microbial influences on biology).

This chapter has dealt primarily with knowledge that I, as the writer, possess and don't necessarily include in the text. These examples demonstrate the necessity of accurate scientific information in worldbuilding. By tapping into my background as a scientist, I was able to synthesize scientific research with my creative practice, developing a speculative future that looks at what is currently in the present and what may be. With my worldbuilding, I hope the natural laws of my world give it veracity for the reader so that they can connect the familiar elements they resonate with to the strange and new. As critic Matt Webb says of science fiction, "The reader can readily

draw parallels and discover new truths. And the new truths are about the present, of course.” I hope the careful work I have done establishes a firm worldbuilding foundation and framing will allow readers to leave my text with a broadened perspective on our world now.

*Chapter 3: Putting Science in Fiction***Telling it like it is.**

As scientific research and thought become more commonplace in our cultural discussions, not only are writers—including those who do not consider themselves science fiction writers like Ian McEwan or scientific literary writers such as Richard Powers—writing about the scientific realities of our present world, but readers also expect and enjoy a certain amount of overt information, particularly in a science fiction novel. Studies have shown that part of the pleasure science fiction readers find in the narrative comes from this transmission of information about technology and science (Menadue). The pleasurable transmission of information is something a writer of science fiction must keep in mind when attending to their craft.

The research of Kristen Koopman corroborates this claim. Using GoodReads, she examined over 5000 reviews of 20 works of speculative fiction that had been nominated for The Hugo Award for Best Novel,²² between 2008 and 2012, attempting to understand how scientific information is controlled, imparted, and received in science fiction. Koopman's research demonstrated that "different reviewers may read the same text with different expectations, different preferences, and different opinions" (*Who Speaks Truth* 86) with respect to how information is conveyed. She goes on to say:

Didactic intent was sometimes welcomed, with reviewers noting that they "learn[ed] a tremendous amount" (4315), calling books "hugely interesting and educational" (2485) and "thought provoking" (4123), and celebrating that they "felt like I learned so much too! I kept having to take breaks to google different subjects discussed in this book."

²² The most prestigious science fiction award currently.

(1355) Intellectual stimulation and elevating the delivery of speculative information both function as features that can redeem an overly dry text. (88)²³

However, other critics have acknowledged the danger that “‘science content may be too dense, destroying the suspension of disbelief in the narrative and the artistic integrity of the work’ in the form of an ‘information dump’”²⁴ (Haynes qtd. in Hamann-Rose 41).

For a wide audience, there seems to be a “sweet spot” of providing the right amount of information to maintain reader engagement in the story. However, that sweet spot differs depending on the narrative priorities of the text. Both Andy Weir’s *Project Hail Mary* and Anne Patchett’s *State of Wonder* were well-received despite being vastly different in the amount of scientific information they provide and the strategies they use to transmit that information (*The New York Times*; Bourke).²⁵ Still, even though, as Hamann-Rose asserts, instruction vs pleasure is a false dichotomy (Hamann-Rose 44), the consensus seems to be that writers must avoid the dreaded “infodump” because they “break suspension of disbelief by revealing the artificial nature of narrative—rendering the labor of the author visible” (Koopman, *Who Speaks Truth* 146).

However, one reader’s infodump is another’s necessary and pleasurable moment in the text. Cory Doctorow is notorious for his information-laden novels, such as *Walkaway* (2017) and *Little Brother* (2008),²⁶ causing some reviewers—who enjoy

²³ These numbers are Koopman’s nomenclature to distinguish different reviewers while preserving their anonymity in her work.

²⁴ (These are the page numbers from Haynes’ own work: 138, 145).

²⁵ Weir’s *Project Hail Mary* spent 8 weeks on the bestseller list, summer 2021. Patchett’s *State of Wonder* was shortlisted for the Wellcome Trust Book Prize for the finest book that engages with medical themes.

²⁶ In *Little Brother*, he even provides a recipe for cold-brew coffee. One I’ve made and enjoyed.

his novels nonetheless—to describe his work as essays turned into novels (Koopman, *Who Speaks Truth* 85). At a 2017 reading at Mysterious Galaxy Bookstore in San Diego, California, I asked Doctorow about the issue of the infodump in science fiction. He smiled and said, “There’s no such thing,” adding that telling (as opposed to showing) was important in science fiction.

The dichotomy between showing and telling will be familiar to most novelists and is attributed to Aristotle’s discussion of action in drama to create more realistic characters. I, myself, admonish my students to avoid exposition (telling) when showing something in a scene is an option. However, as E.M. Forster, in response to Aristotle’s advice, notes, “tell[ing] his story about human beings” is what a good writer does because it can provide hidden interiority and significance to the story: “The speciality of the novel is that the writer can talk about his characters” (Forster 66, 84). Further, as the writer Jeannette Ng notes, “‘Showing’ relies on the ability to draw on a pre-existing network of iconography and tropes that have been established by other works and broader culture.” When what the writer is trying to convey doesn’t have a mainstream cultural equivalent (as Ng notes is the case with marginalized cultures and voices), or is, perhaps, a complex new scientific idea, “showing” may just leave the reader confused as to what she is supposed to know. David G. Hartwell claims that while science fiction “is about the beauty of truth, [...] about the emotional experience of describing and confronting what is scientifically true[, it relies on] education and general knowledge of science.”

When writing about the strange and new, overt communication through exposition can sometimes serve as the essential bridge between familiar and strange that creates greater engagement for the reader with the novel. Granted, there are a lot of broad tropes in science fiction that can lend themselves as shorthand for significance

and meaning when showing something in scene—such as AI-assistants to signify a technology status or a “warp drive” that indicates we are in a universe with faster than light travel (Ng talks about the shorthand of a white dress to symbolize a wedding)—but when creating a strange new world with unfamiliar natural laws, there is a need for imparting information through exposition.

Deciding how much information needs to be explained overtly in the story versus hidden in worldbuilding is an element of craft that I found important to master. Even more than realist fiction, science fiction requires textual space to convey information to the reader. While didactic communication of information is warranted in this genre, I wanted to avoid so much informational intrusion that my readers were pulled out of the story my characters were living. As Asimov describes science fiction, my novel is a story “in which the details of science play an important role and in which the author is accurate about those details, too, and takes the trouble to explain them clearly” (qtd. in Westfahl 159). However, what I hoped for was a balance between direct explanations and other methodologies of direct information transmission while grounding it in human body experiences.

Say it to me straight.

In her research, Koopman identified eight techniques for exposition in speculative fiction. While an author may tend to use one more than others, most writers employ a mix of these techniques to convey important information in the text (see table 1). In analyzing how I presented scientific information in my own work, I found that I most commonly used four of Koopman’s strategies: Characters’ Knowledge, Temporality, Dialogue, and Seeing-In-Use. Characters’ Knowledge is using the “filter of the character’s knowledge” (49) to convey information; I used close third point of view

(POV)—more specifically limited-third—and the multi-POV structure of my novel to employ this technique. Temporality, according to Koopman, breaks the narrative flow (the “time” of the story) to provide information through a direct authorial POV intrusion. Dialogue is the most straight-forward of the exposition strategies Koopman identifies; it is relating information through speech. And finally, with the strategy of Seeing In-Use, I “use[d] specifically-curated details in narration to lead the reader to draw conclusions without the narration or a character explicitly saying that information” (51). In the course of my practice, I attempted to vary how information is revealed in the above forms of exposition throughout the course of my novel to maintain narrative engagement.

Table 1
 The Exposition Techniques Employed by Speculative Fiction Authors, According to
 Kristen Koopman (2022).

Technique	Description
Temporality	A break in the temporal flow of a narrative to deliver exposition.
Focus	A deep level of detail used to describe or analyze a new concept.
Register	A shift in the narration to an external source that is posited to exist within the universe of the narrative.
Didactic Tone	An explanation provided, either in-character or by the narration, for the express purpose of teaching.
Characters' Knowledge	Information conveyed to the reader through the filter of a character's knowledge, particularly the point-of-view character.
Dialogue	One character tells another character information that is, coincidentally, passed on to the reader.
Seeing In-Use	The use of specifically-curated details in narration to lead the reader to draw conclusions without the narration or a character explicitly saying that information.
Extradiegesis	Supplementary materials that do not exist within the world of the narrative, such as Author's Notes, Notes to the Reader, and so on.
	(Koopman 49-51)

Characters' knowledge(s)

According to Koopman, using characters' knowledge as an exposition strategy provides information "through the filter of a character's knowledge, particularly the point-of-view character" (*Who Speaks Truth* 50). One of the choices I made for my novel was to write it primarily in a limited-third point of view (POV) from the perspectives of five different protagonists. According to editor and author Tiffany Yates Martin, the limited-third POV "tethers" the author "to a single character—you can't break free. You can go inside her head and be privy to all her thoughts, but no one else's. Yet as an external observer you can also offer objective commentary on the character, and know more than she knows." I liked the constraint of the limited-third person because I wanted to inhabit my characters without mediation, yet I also liked the freedom it gave me to pull slightly away and provide extra-character context through the technique of Temporality discussed in the next section.²⁷

From Jules Verne and Sinclair Lewis to Michael Crichton and Verner Vinge, science fiction writers often have scientists as main characters or important side characters in their works. From a technique standpoint, this strategy makes sense: it benefits the story to have a character who possesses the specialized knowledge you want to impart. Greg Bear uses similar strategy in his fiction, particularly in *Darwin's Radio*, to relate complex scientific knowledge about viruses, microbes, and human genetics.

Inspired by the Human Genome Project-spurred revolution in thinking about what makes us human, Bear informs his readers in his afterward (Koopman's identified technique of extradiegesis) that he is performing a thought experiment on

²⁷ Limited-third POV is in contrast to deep-third POV which is similar to limited-third except that the narrator in deep-third is the character with no chance for a wider perspective. In this way, deep-third employs the narrow POV of first person. Close third encompasses both of these third-person POVs.

the future of human evolution extrapolated from studies on endogenous viruses and how certain species rapidly adapt to environmental pressures. In the story, women worldwide begin to miscarry deformed fetuses then a month later discover they are pregnant again with an infant who has 52 chromosomes (humans have 46, normally). Scientists figure out that this event has happened in the past, and is controlled by a human endogenous virus,²⁸ which they name SHEVA, that somehow is able to hijack the human cells it has been sitting quietly in for millennia and make infectious particles that can be laterally transmitted. Bear explores the social ramifications of a “disease” that causes miscarriages and birth defects. His scientist protagonists speculate that this isn’t a disease but an evolutionary event. Scientist Kaye Lang intentionally becomes pregnant with no intention of aborting the second chromosomally aberrant fetus to prove that she and a small group of scientists are correct that this is an evolutionary transition to a new type of human.

The text begins with Kaye in the Republic of Georgia to meet with the director of the Eliava Institute.²⁹ She is hoping to partner with them to bring phage therapy to the United States. But she gets called away by the UN to inspect a mass grave that has just been uncovered.

²⁸ Endogenous viruses are retroviruses like HIV that have managed to incorporate into the DNA of a sex cell and then cease to make virions. These viruses then are passed down generation after generation. They no longer infect or make the host sick; these viruses are content to just be replicated when the host cells replicate. Currently, it is estimated that humans are about 8-10% viral. As of the time of this writing, we aren’t sure if most endogenous viruses serve any functional role in our bodies or if they are just hanging out.

However, it does seem that the gene to make a placenta is viral in origin—our Ur-mammalian ancestor survived an infection and genome incorporation and then was able to make placenta by activating the instructions in the viral genes. This speculation forms part of my worldbuilding framing: because the humans in my world have manipulated our microbiota, the bacterial signaling to activate this virus gene has gone awry and pregnant women’s bodies aren’t able to receive the instructions to make a placenta.

²⁹ The Eliava Institute is located in the Republic of Georgia and is the longest-standing research facility on bacteriophages for treatment of bacterial pathogens. There’s an interesting and sordid history around this facility that is nicely told in Anna Kuchment’s *The Forgotten Cure: The Past and Future of Phage Therapy*. For a contemporary narrative on phage therapy, see *The Perfect Predator* by Steffanie Strathdee.

Kay examined the boot. [...] The leather was hard as a rock. She peered into the interior. Dirt, but no socks or tissue—the boot had not been pulled from a decayed foot.

Staged, Kaye thought. (Bear 20)

Kaye's knowledge allows her to note that there is something sinister going on with the way the Russian authorities are handling this mass grave. Sure enough, the UN is promptly expelled from the site, and Kaye loses her deal with the Eliava institute.

In my own novel, I have three scientist protagonists—Maeve, Samuel, and Isaac—with Raiah being a nonscientist but one who has background knowledge because of her father. Though all biologists, each has a different specialty: Samuel's is microbial ecology in the human body, Maeve's cell signaling, and Isaac's genetics. In my scientific research on the human microbiome, I found that a synthesis of all three of these disciplines was important to understanding just how our resident microbes and viruses affect us as walking ecosystems. I wanted to have that same synthesis in my novel, and used the interactions between these three to achieve that.

However, I was also able to use each character's knowledge in isolation to establish the pieces of information I needed the readers to collect over the course of the novel. The following scene illustrates using the character knowledge of Isaac Pickwell, geneticist. He's comparing the metagenome of Raiah with the new surrogate, who we will later learn is Veronica.

It was so much to see, billions of organisms to form one human, lines of ATCG and AUCG streaming across the wall in rainbow hues that indicated actual or probable function for sections of the code.

With a shake of his head, he moved his long fingers across the screen to filter the data to only genes that were being transcribed above

a certain threshold. Then, he entered another gene sequence in the new experimental surrogate's data, viral this time, expecting zero results like he'd gotten from the last three surrogates, but a match lit up, the code uncolored to indicate no function assigned. (DBC 93)

Because we are inhabiting his POV, we don't have explanations of what are ATCG and AUCG³⁰ nor the significance of what a transcription threshold is—Isaac knows this. He's working through his expertise in real time to solve the problem of why Raiah keeps miscarrying.

Here Isaac's character knowledge serves as a puzzle piece as to why there's a problem with women staying pregnant. This, I hope, sets the reader up for a later moment where Maeve explains to Veronica that the “placenta fails. There's something getting mixed up in the signaling between host—I mean the pregnant person—and fetus” (DBC 326). My hope with using the knowledge of my characters is that I will be able to include the complex scientific information about humans as ecosystems in a way that feels natural to my characters.

Temporality

Temporality is the break of the narrative flow by the author to provide information that the character realistically would not be conscious of in that moment (Koopman, *Who Speaks Truth* 49). This strategy is useful for science fiction writers even if they have characters who possess the scientific knowledge. There are moments when it would be false for the POV character to sit and think about information they are familiar with or may not know at all. Thus, the technique of Temporality used in the

³⁰ ATCG and AUCG are the four DNA and RNA nucleotides, respectively: adenine (A), thymine (T), guanine (G), and cytosine (C) for DNA. In RNA, thymine is replaced by uracil (U).

context of a limited-third POV allows the author to pull away from the characters' heads to convey necessary information directly to the reader.

In Bear's *Darwin's Radio*, after she sees the mass grave, Kaye returns from her trip and is talking with her husband, Saul, about the company that they share. Saul speaks knowledgeably on their research and funding:

“We demonstrated we can isolate the bacteriocins, purify them, produce them in neutralized form in bulk—then activate them. [...] We're so far ahead of Merck and Avantis they can't even spit at our butts.”

Bacteriocins were chemicals produced by bacteria that could kill other bacteria. They were promising new weapons in a rapidly weakening arsenal of antibiotics. (Bear 71)

Both Kaye and her husband are scientists, so they have direct knowledge of scientific elements in their fields. Here Saul speaks knowledgeably about their current research. Kaye already knows all these things, so he doesn't need to explain them to her. However, the reader doesn't. So, Bear uses an authorial break (Temporality) to explain bacteriocins yet keep the story going.

Early in the novel, I knew the reader would be unfamiliar with the world and would need more clues as to its natural laws. I found that I needed to have more moments of authorial exposition via Temporality. The early sections were also where I worked to blend the familiar with the new and strange. The Raiah Prologue that I discussed in Chapter 2 of this thesis demonstrates this type of authorial intrusion.

There were moments in the text where I decided that I needed to preserve the authorial intrusion despite my reader's suggestion otherwise. In the Samuel Prologue, Samuel looks at an image of a capsid. I initially called it a “viral capsid” (see figure

3) thinking that the context of “viral” would help the reader understand what a capsid was (see figure 4). But my advisor wondered if the combination of words was perhaps more confusing than helpful as “viral” has a specific popular culture connotation.

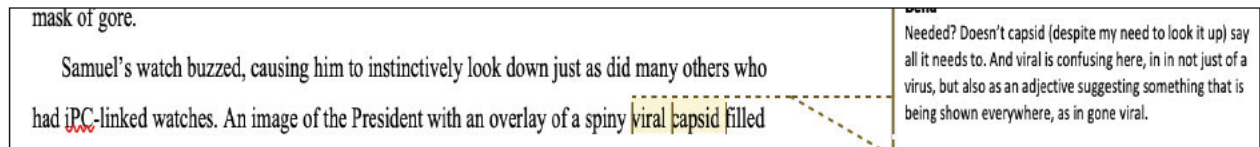


Figure 3. A comment questioning my redundant use of “viral” with “capsid” and cautioning that “viral” has connotations I may not desire.

This moment is a telling example of the balance of information I have attempted to do in this novel. I wanted to provide this information so that my readers wouldn’t have to leave the story to look up “capsid,” so ultimately, I revised this moment to “virus’s capsid” to preserve the contextual clue without the connotation.

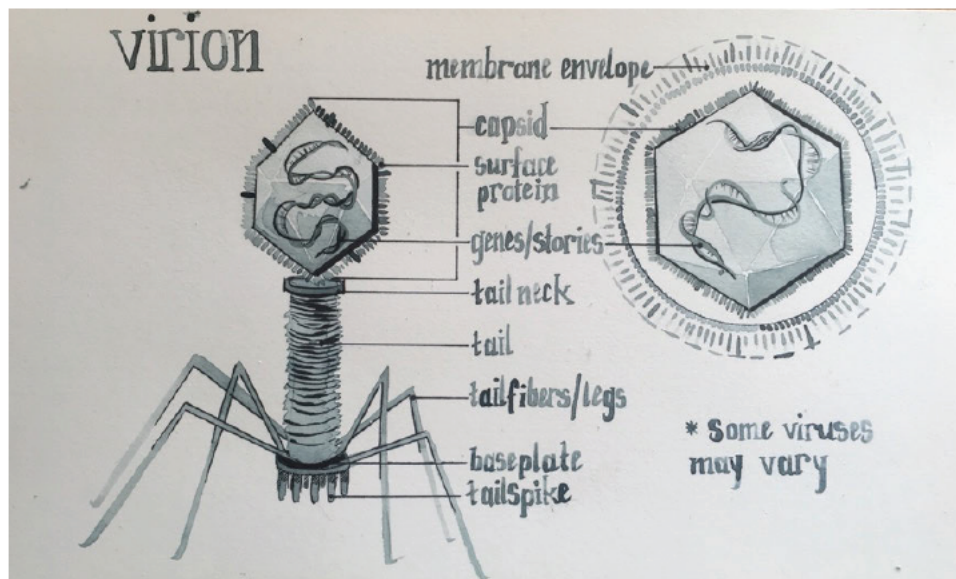


Figure 4. Illustration by Leah Pantéa of a T4 bacteriophage and enveloped virus, labeling parts of a virus including the capsid.

Another example of Temporality occurs in Section 3, when Samuel takes Maeve to the travelport after he rescues her from being a human research test subject:

With intense storms and sweltering temperatures restricting air travel in locations across the world, airports had culled into the few geographic spaces that could guarantee timely takeoff and landing schedules, high-speed trains bringing travelers to those facilities. The nearest airport to Reno was the consolidated Central Plains Complex in Idaho. High-speed trains left Reno for the few mega-airports scattered around the continent, making the travel hub a spaghetti bowl of twisting track, rental car facilities, hotels, and self-care units. (DBC 208)

Here, I pull out of Samuel's head to provide setting. Samuel would not necessarily think about the status of air travel because he'd already be familiar with it. However, since the natural laws of the world in *The Desert Burns Clean* are rooted in the speculations of the effects of climate change, I felt that including what would happen to air travel would be an enriching detail. I do not come to this knowledge casually: my partner is a commercial pilot, so I hear weekly about how increasing and unpredicted storms hamper flights as well as the physics of flight which would make taking off in places that get too hot impossible (already there are occasions in places like Phoenix, Arizona where planes cannot generate enough lift to take off because the air temperature is too high). The above Temporality exposition serves to situate Samuel and Maeve in a physical world—one we are becoming very familiar with: just recently in Summer 2022, a record heat wave roiled through Europe and the UK.

Dialogue

Using conversation to convey information to the reader is not limited to science fiction. However, there is a common pitfall in science fiction when the authorial goal of a text is to convey information rather than let her characters live human lives; it is

called the “As you know, Bob” moment. This phrasing is “pointing out the absurdity of one character telling another character something they already know for no discernable reason other than to convey that information to the audience” (Koopman, *Who Speaks Truth* 56). In these moments, informational transmission via dialogue becomes stilted and the characters become merely puppets, divorced from their bodies.

One strategy to use dialogue to convey information and keep it authentic is to have an expert talk to a lay audience. In *Darwin’s Radio*, Bear often uses this strategy, particularly in the form of press conferences being given about how women are pregnant with new-human fetuses.

[Reporter] “Do other old viruses exist in our cells?”

[Kaye] “The latest estimate is that as much as one third of our genome could consist of endogenous retroviruses. They sometimes form particles within the cells, as if they were trying to break out again, but none of these particles have been efficient—until now.”

[Reporter] “How did they get into our genes?”

[Kaye] “At some point in our past, a retrovirus infected germ-line cells, sex cells such as egg or sperm. We don’t know what symptoms the disease might have caused at that time. Somehow, over time, the provirus, the viral blueprint buried in our DNA, was broken or mutated or just plain shut down. Supposedly these sequences of retroviral DNA are now just scraps.” (77)

Here, Kaye is explaining to the reporter (and the reader) the mechanism of how these new-human fetuses might actually occur.

Because my goal with this novel is to convey information in a way that feels true to a lived experience, I needed my dialogue to do more than merely have two

people chat to communicate a scientific concept to the reader. Burroway says that, in fiction, effective dialogue must do more than one thing: it provides information but also should characterize, move the story forward, or enrich understanding (78). Koopman calls this work embedding “facts in networks of meaning” so that the reader sees how certain knowledges play out in relationships with other humans as well as with the wider world (*Who Speaks Truth* 58). In the following excerpt, I attempted to use dialogue to communicate scientific information but also to characterize Isaac and Raiah as well as make connections between science and art. Isaac is answering Raiah’s query about his work.

“I think the hope is that in being able to read the language of life in one organism—whether it’s DNA or RNA—we’ll be able to construct the entire narrative of an ecosystem. So, I look at how individual cell types—yours, mine, a microbe’s, a goat’s—and viruses tell their biological stories and how those stories create a whole narrative that makes an organism or a colony or even an entire ecosystem.”

“The story of an ecosystem? My daddy never talked about it like that.”

“Um yeah, like how your hair grows. That’s a biological story written in your genetics and then told by your cells. So, I would look at that story and how it is read—expressed—then figure out how it contributes to the larger story of what makes you, you.”

“Oh, like when I dance. The choreographer teaches a phrase—a series of movements—and then I ‘express’ those moments in how my body moves.”

Isaac had never heard dancing called a phrase before. “So the ‘phrase’ you learn isn’t exactly what you dance?”

“No. That’s the baseline, the structure of the movement. And as I move my body, the phrases shift to reflect my unique physiology. It’s the same phrase but also unique to me.” (DBC 361-362)

In this dialogue, I am making a direct comparison between art and science and how we can think of them in similar ways—dance-as-language and genes-as-language that both use phrases.

However, I did take the risk of having “As you know, Bob” moments when I really needed the reader to understand a key aspect of the plot. In the conversation excerpted below between Isaac and Samuel, I needed to finally reveal why Maeve was a test subject, Jes’ nefarious plans and the scientific feasibility behind them, and also tell Samuel what was going on with Isaac, Raiah, and Veronica. No small feat.

Samuel leaned forward, quickly scanning the two women’s profiles, swiping through screens of data. “They’re really similar, and with the manipulation done to Maeve, they’re even more so. Why?”

“Think of it as if someone needed a bone marrow transplant. You’d have to find a donor with a strong match to guarantee success, right? This is analogous.” Isaac paused as if searching for the right words.

“Come on Isaac, I’m not a first-year grad student here. You don’t need to dumb this down.”

“Jes needs a receptacle for a consciousness transplant.” Isaac bit off the words.

“What?” Samuel laughed. “That’s ridiculous and you know it. Science fiction.” But as Isaac’s face remained straight, Samuel stopped laughing. “You can’t be serious.” (DBC 305-306).

In this dialogue, I attempted to characterize Samuel and Isaac as well as add a sort of meta-narrative perspective to the idea of a consciousness transplant. I anticipated my readers’ protests in Samuel’s fictional reaction. I also covered the narrative problem that Samuel wouldn’t need a lot of explanation by having him overtly call out Isaac for laboriously explaining something he already knows.

Seeing In-Use

With all the above strategies for exposition, I still run the risk of “infodump” as discussed earlier, or at the very least breaking narrative flow with too much information. Seeing In-Use incorporates information directly into actions and scenes without any tags to tell reader explicitly that a knowledge transmission is occurring. Amongst the techniques for relaying information, Seeing In-Use most closely approximates the experience of “showing.” Unlike worldbuilding—where the foundation and framing information is minimally or not at all revealed in the story—the intention with Seeing In-Use is to overtly transmit information to the reader.

In *Darwin’s Radio*, Bear uses Seeing In-Use when he’s describing the changes that humans undergo as a result of the genetic remodeling being done by the viral infection. Even though the pregnant mothers and infectious fathers do not increase in their chromosomal count, they do begin to develop some of the traits that their evolved offspring will have. One of these traits is a stronger sense of smell. The reader must know this information so that she can understand how smell becomes a powerful bonding component between parents and their new-human offspring. By using Seeing

In-Use, Bear doesn't outright explain this information. Instead, he has Kaye and her lover, Mitch, begin to experience them.

"I smell you," Kaye said.

[...]

"You're fertile," he said.

"How the hell do you know?" Kaye asked.

"I can see it in your skin. I can smell it," Mitch said.

[...]

"You're fertile, too," she said. "You didn't say otherwise."

"Mm."

She lifted her torso again, rolled off him, and swung around to face him. "You're shedding," she said.

Mitch screwed up his face in puzzlement. "What?"

"You're shedding SHEVA. I tested positive." (356)

Kaye and Mitch have an enhanced sense of smell because of their active infection with the SHEVA virus. Bear doesn't overtly tell his readers this fact; he relies on the reader connecting this first awareness of smell to Kaye's mention that they are both infected with the virus. It isn't until the end of the book that Bear reveals their new-human daughter has a heightened sense of smell as do they which they use as a way of enhanced communication. However, this introduction of smell might not be linked to the virus but instead to Kaye and Mitch's sexual interest in each other. It isn't until almost 200 pages later, that there is another confirmation that enhanced sense of smell is an infection side effect. This moment of Seeing In-Use demonstrates the "clues" a reader must pick up as well as how those clues can be missed.

In my novel, *The Desert Burns Clean*, I attempted to put as much information as I could into narrative action. For example, I often have Isaac working in his laboratory. In the following scene, he's substituting two of his and Raiah's embryos for Jes' clones.

Working quickly to avoid thawing the embryos of Jes' clones, he plucked four from the box, placing them in a dry ice bath. For the next code, he hesitated, typed a partial code which he canceled, then punched in the date he met Raiah. This released another nondescript box that he took back to his sterile hood, quickly pulling two tubes from that and placing them with the first four and returning the source box. Finally, he combined the six tubes into a new box he'd already marked in black ink, "Embryos - Trial 5," adding that box to the freezer, coding its release number with that of the trial. The entire procedure took less than three minutes. (DBC 97-98)

In reality, bench research for molecular biology is putting tiny amounts of liquid into tiny test tubes into tiny boxes that go into very cold freezers. That is what Isaac is doing here. Not exactly riveting. But here, I am hoping that my readers gain some understanding of actual lab work.

Seeing In-Use requires the most co-generation of knowledge from the reader since there isn't an explicit transmission of knowledge. Thus, I found that I used this strategy more at the end of the novel when I could assume that my readers were familiar with my world. Koopman argues that Seeing In-Use can be connect to the scientific method: "much as scientists draw their conclusions from observations, seeing in-use relies on readers to derive conclusions from the curated observations in the texts" (Koopman, *Who Speaks Truth* 52).

Discussion.

Conveying scientific information is an important aspect of science fiction, and readers derive pleasure from this transmission. Because of the complexity and potential unfamiliarity of the speculative world, a certain amount of exposition is required. This exposition attempts to create a believable and engaging world that is true to its natural laws. Thus, the reader can make emotional and moral decisions about the story because she “knows what is at stake” through the scientific explanations (Hamann-Rose 46). Building a complex world requires a blend of the familiar and the strange, with the amount of overt information conveyed to the reader transmitted with a variety of exposition techniques

Although ambitious for a first-time novelist, I found that having five limited-third POV protagonists helped me to portray accurate scientific information and create an engaging narrative. Having a mix of protagonists with varying levels of scientific knowledge allowed me to communicate information across different areas of scientific expertise (such as Isaac’s knowledge of genetics vs Samuel’s of microbial symbionts) as well as examine aspects of the story from multiple perspectives (such as Maeve’s and Samuel’s diverging opinions on the humanity of the botch). I found my use of the technique of Temporality to be inverse to that of Seeing In-Use; at the beginning of the novel, I provided more authorial information than I did at the end of the novel. The techniques of Characters’ Knowledge and Dialogue, I used evenly throughout the text.

Understanding these techniques enabled me to make narrative choices about how I conveyed overt information to my readers. They provided me with a toolbox so that I could avoid long moments of didactic prose. This enabled me to explore my

research question of accurate science in a science fiction story that conveys a true-feeling lived experience. My next chapter will address my work in creating characters with lived body experiences as a strategy to engage the emotional commitment of my readers.

*Chapter 4: Embody***The body makes us human.**

Among other goals, my novel aims to be a thought experiment that explores what could happen as humans pursue optimal health—what are the consequences (social and individual, intended or otherwise). In exploring these ideas, I didn't want to divorce the thought experiment from the fact that we are humans with lived body experiences. I wanted to create real people. As author Thi Bui says, “real people laugh and cry and go to the bathroom and have sex and children.” Within the novel, I attempted to include all these elements, and more, to create fully fleshed, human characters.

I've established throughout this piece that part of the delight and entertainment readers of science fiction derive from this genre is the transmission of information. However, that information must be married to a story or it ceases to be science *fiction*. Koopman's research into reader reviews of diverse speculative fiction confirms this point. If an author neglects the story, it:

no longer conform[s] to the expectations readers have of novels (or, more generally, stories) [...] This criticism implies that the transmission of speculative information cannot be the primary point of the texts; there is something that differentiates "a blog post" or "GRRM's recitation of the Westeros phonebook" from a satisfying novel-reading experience. (*Who Speaks Truth* 86, 87)

In the early 20th Century, Hugo Gernsback (of the prestigious Hugo Award in science fiction), who did much to shape the popular idea of what science fiction is, called for “a science fiction story [that] must be an exposition of a scientific theme and it must be also a story,” stressing the importance of technological accuracy but told in an

interesting way that delights and entertains. Readers of science fiction desire information but they also want a story that delights and entertains them. One of the ways I hoped to accomplish the latter was to attempt to create characters who feel human.

To access embodied human experience, Ursula K. Le Guin (amongst others) considers the importance of characterization, but denies that the science fiction of her time does it well. She explains in “Science Fiction and Mrs. Brown”—referencing Virginia Woolf’s discussion of characterization using the archetypal character of Mrs. Brown—that fiction deals with subjects, that is, humans, yet some genres of fiction better access our humanness. Le Guin questions whether science fiction writers can capture this humanness contained in Mrs. Brown, asking science fiction writers if “we [are] trapped for good inside our great, gleaming spaceships hurtling out across the galaxy [...] ships capable of anything, absolutely anything, except one thing: they cannot contain Mrs. Brown” (*The Language of the Night* 103). While Le Guin makes some important points, I disagree with her conclusions that science fiction is stunted in its ability to provide real humans as characters. Le Guin’s own oeuvre as well as stories by her female peers like James Tiptree Jr. (the male pen name of Alice Sheldon)—such as “The Girl Who Was Plugged In”—contradicts her posited conundrum. Characterization—that is, creating real humans who live and breathe in the story—is important for accessing a true feeling of lived experience. I believe that science fiction, particularly science fiction that looks at human biology, is well-suited to depict these lived experiences because the set of knowledge provided in this discipline directly relates to the physical body.

Despite this suitability, I discovered, during my practice, that it is no small feat to manage effective characterization of embodied characters while conveying complex

scientific information. I chose to address this challenge by creating a narrative that accesses multiple points of view across genders and scientific expertise. They all wrestle with issues that are common to all humans—relationships, loss, physical deprivation—sometimes alone, but more often in relationship with each other. Since I wanted to root my scientific information in human lived experiences, I found that focusing on my characters and how they experience the world was an important aspect of my practice.

Experimenting with POV is not new to speculative fiction. Author N.K. Jemisin notes that experimental POV is “not really rare in literary fiction, or more literary-oriented fantasy subgenres (e.g., slipstream, New Weird). I went with it because that was how the story needed to be told” (Jemisin qtd. in Koopman, *Who Speaks Truth* 126). I value Jemisin’s emphasis on finding “how the story needed to be told” through POV that allows for character complexity. I found using multiple POVs essential not only to being able to overtly communicate scientific information but also to my accessing the varied embodied experiences of my characters.

Whenever I felt myself veering into information transmission, I returned to how a human would feel the information as a subject, relying heavily on my own lived experience as a scientist in a human body and remembering Donna Haraway’s ideas that knowledge is situated in our bodies and environmental context. Haraway challenges the idea of dispassionate objectivity in science, claiming there’s a “particularity and embodiment of all vision. [...] We need to learn our bodies,” she continues, as a way to “reclaim that sense to find our way through all the visualizing tricks and powers of modern sciences and technologies” (582). Particularly in my character, Maeve, I found space in her POV to portray her as a person with great scientific expertise who is simultaneously a wounded and healing subject.

By attempting to create characters with sensory and physical moments in the story, I am trying to “project [the] storyworld through the embodied perspective of the protagonist[s],” which I hope will then similarly affect the reader (White 535). Studies on language comprehension suggest that when a person comprehends heard or read words, the same part of the brain activates as would have when experiencing through their senses what is being described in the words (Zwaan). Further, both the reader and the subject hearing what they read will provide sensory experience beyond that of the actual words. Additional exploration in this field of embodied language comprehension also indicates that beyond envisioning words, other corporeal experiences like motor function can be enlisted when a person comprehends words (Fischer and Zwaan). Thus, it is not too much of a stretch to go from creating embodied characters to desiring to evoke a sympathetic embodied response in the reader: “when engaging with a work of fiction, readers tend to stimulate both the spatiotemporal standpoint and the emotional perspective of the protagonist” (White 547).

What I found challenging was putting the ephemeral moments of feeling in our bodies into words. Often these experiences resist expression in language, causing us to use metaphorical descriptions, such as tropes, in the hope of evoking a shared body experience in the reader/listener. Le Guin claims that the novel is necessary to explain that which cannot be clearly stated (“Introduction”). And I hope to have demonstrated that in *The Desert Burns Clean*.

Information is experienced in a body.

We live in bodies, and we learn in our bodies; nothing known is separate from our physical situation in the world. According to philosopher Shaun Gallagher, “nothing about the human experience remains untouched by human embodiment” (247). In my

review of how authors convey the physicality of the body, I noted that many used the act of sex or the tension between our cultural male/female dichotomy as a sort of shorthand for lived body experience. While I also include moments of sexual intercourse in my novel as well as heteronormative male/female tensions, I also wanted to find examples of how one might go about communicating other aspects of physicality in our bodies such as the weird wonder of how our world works, the unique way a person might think, the stress of being threatened, or a quiet moment of safe companionship.

However, what was of most interest to me was how I could actually incorporate scientific concepts in body experiences, using my various POVs as windows in. My novel is rife with attempts at connecting my characters to their body: Raiah induces lactation, Samuel feels pain in his sinuses, Veronica undergoes a caesarian—to name only three. However, for the sake of this contextual, I will examine two intentional moves I made to embody Isaac and Maeve. In these examples, I will discuss my use of Isaac's POV to take complex knowledge and emotional state into physical experience and Maeve's POV as a way to convey the aftermath of trauma. Of note, in embodying Maeve's trauma experience, I ultimately decided to avoid a scientifically established corollary to her split selves.

Isaac

As much an artist as a scientist, Isaac experiences his research in his body. I wanted to find a way to demonstrate his lived experience with his scientific passion. So, I created a trope that could signify Isaac's sensation of contentment when things "clicked" for him. Critic Guillemette Bolens claims that often tropes "play a central role in the kinetic style of a discourse" through the tropes being "sensorimotor

configurations” (66). Using Isaac’s stick, “two polished pieces of wood that were held together by a piece of thread running through the center” (DBC 43), I established a trope for how he experiences the world in alignment or out of alignment.

In examining how science fiction writers attempt to bring abstract ideas into a lived body experience, I noted that tropes (whether overtly stated or not) played a large role. For example, author Cixin Liu alludes to the trope of a spider’s web to transmit a physical experience with protons unfolded in various dimensions—theoretical concepts that don’t have known bodily sensations. Concerned primarily with physics, Liu’s novel, *The Three-Body Problem* (and the subsequent two in the *Remembrance of Earth’s Past* trilogy), span centuries of human social and technological evolution in the wake of learning there’s an incoming (in 450 years) alien attack from the depleted planet Trisolaris and the aftermath of that invasion. In this often-meditative trilogy, Liu moves through the POV both of various human protagonists and of the Trisolaran invaders as he attempts to convey the weird wonder of particle physics.

In one scene, the Trisolarans attempt to unfold a proton into two dimensions so that they can create a smart weapon to stymie human technological development on earth. Liu packs dense philosophical musings and physics into just a few pages, making these practically incomprehensible concepts (to lay readers at least) comprehensible by tapping into the physical sensations and responses of the people of Trisolaris when the attempts at unfolding a proton takes place. One of the unfolding failures reduces the proton to a single dimension—a line. Though this line was “infinitely thin” (Liu 363), it still could fall to the planet as reflective silky strings.

“These things are so annoying.” The princeps brushed his hand against his face over and over. He and the science consul were standing on the

wide steps in front of Government Center. “My face always feels itchy.”

“Princeps, the feeling is purely psychological. All the strings added together have the mass of a single proton, so it’s impossible for them to have any effect on the macroscopic world. They can’t do any harm. It’s as if they don’t exist.”

But the threads that fell from the sky grew more numerous and denser. [...] Although the one-dimensional string could only be seen under light and couldn’t be felt, people became upset. (362 – 364)

This scene extrapolates what physical effect an unfolded proton might have, also noting psychological responses to the visual weight of seeing so much light, which feels to the Trisolarans almost like a physical burden. Similarly, to how Bolens describes a passage by Merleau-Ponty, Liu “relies on his reader’s ability to generate a necessarily dynamic multimodal simulation, linking body sensations” (Bolens 67)—the reader could connect the sensation of walking through an almost invisible spider’s web to what it would feel like to brush against a proton unfolded to the first dimension. Using these images and our own human responses, Liu conveys experience of the weird wonder of the world in bodily sensations.

I wanted to impart a physicality to Isaac’s research by connecting it to his sense of contentment when his stick clicks. I attempted to weave the trope throughout the text, but the first time we learn about his stick and the “click,” I intentionally used another physical scenario: a stone in Isaac’s mouth. “Instead of taking out his stick to sooth his thoughts, he let the stone lightly click against his teeth, enjoying the combination of sound and taste with the physical reverberation in his jaw. Click, click, click” (DBC 42). The sensation of an object clicking against teeth is one that many (if

not all) humans have felt. It can be both a disconcerting experience and one that is soothing. Regardless of the experience, it is a physical sensation one feels in the bones of the face.

By introducing how Isaac feels about science in this way, I hoped to allow the reader the opportunity to share the physicality of the moment. I also hoped this sensation would then continue in later places where Isaac is doing less kinetic things, such as looking at a computer screen in the scene I referenced in Chapter 3 (481).

Further, I wanted to use this stone scene to communicate what the sensory experience of cellular signaling might be like, connecting to my own scientific research on microbial ecology.

Spitting out the stone, he chose another one, fresh with the slightly fermented taste of brine. All those microorganisms working on unlikely food sources to eke a living from an unforgiving sea. [...] He was sucking on the flavor of life. If he had half the palate his father had, he bet he could discern the different molecular byproducts of these microbes, tracing important biological pathways through taste alone.
(DBC 42)

Isaac is a geneticist, a scientific specialty that studies genomes comprised of DNA or RNA. These molecules are the source text for information the cell wants to pass on or communicate—or, as I like to think of it, tell a cellular story. As part of storytelling, the source text can be translated into proteins. Proteins do many jobs in a cell but they can also act as messengers between cells. For Isaac (and for me), the story is not static genes but molecules that can be shared across many organisms, linking genetics to microbial ecology. Perhaps readers familiar with the briny air and taste of the coast will now think of that sensory moment as an expression of cellular communication.

Maeve

Maeve's embodiment was a little more challenging especially when dealing with a mental illness that is triggered by trauma and an incomplete consciousness transplant. Knowing first-hand the personal nature of how trauma can manifest in the body and psyche, I didn't want to come across as if I were representing all trauma experiences nor did I want to single out a specific mental illness as the "reason" Maeve experiences what she does. Rather, I chose to slip into more fantasy than science, depicting Maeve's body and psyche experience as a trope: a room filled with versions of herself.

I wanted to see how other science fiction writers approached this type of character—or at the very least, a neurodivergent character, so I narrowed my search to writers who focused on human biology with neurodivergent characters who were depicted as humans with agency in whatever form mainstream society took in their worlds.

At first, I examined Nancy Kress' *Beggars* series. In this complex, near-future world, Kress creates protagonists whose internal way of mind-mapping the world is inextricably linked to how they feel the world in their bodies. Kress establishes a complex world of class and biological difference. The premise is that genetic manipulation has advanced so far that parents can pay for desired traits in their children. One such trait is sleeplessness which allows these humans to function in life without sleeping. An unintentional side effect of this trait is a class schism, with the sleepless being a sort of persecuted elite.

The novel doesn't give pat answers or a moral—what Kress' *Beggars* series explores is the prejudice and fear against humans that we perceive as other—often leaving the reader wondering what is actually the most correct and moral way to live.

This productive ambiguity is done through Kress' embodied characters who experience life just as humans experience life: messy, sometimes privileged, sometimes not, sometimes able to manipulate human biology or social structure according to desired outcomes, and more often than not experiencing unintended consequences.

Kress accomplishes this by conveying the unique POVs of some of her characters and using tropes to help make these POVs more relatable. Interesting to me were the thought patterns of Miranda (Miri) Sharifi and Drew Allen, whose thoughts connect to touch and smell as well as sight. In this piece, I will focus on Miri.

Miri has been genetically modified to mentally process her sensory input faster than most humans. She (and others modified the same way) experience their world in a series of connected strings. In a similar way to how you or I may have a non-sequitur thought triggered by something someone says, these humans constantly “thread” through associations, creating complex webs of interconnected and tactile information. Kress represents this by referencing the trope of strings and webs to describe the thought pattern, even using a chart to depict Miri's first explanation of her thought (Kress 251).

Miri's strings are ephemeral. “Strings blew through her mind like clouds swirled from maintenance jets: Loyalty. Betrayal. Self-preservation. Solidarity. Parents and children” (Kress 345). Yet these strings can also become tangible if her links of association become too emotional—the emotions become physical sensations:

Miri couldn't get Tabitha Selenski's death to move from the front of her mind. No matter what she was thinking about—her neurochemical research, joking with Tony, washing her hair, anything—Tabitha

Selenski, whom Miri had never met, tangled, knotted, tied herself into Miri's strings and choked there. (Kress 319)

While I do think that Kress has done great work in depiction of thought patterns, the use of the tropes of strings and webs are commonly accepted in scientific discourse. I wanted to avoid a trope that could be disassociated from the body into the theoretical world.

Early in the novel, I wanted to truthfully convey the sense of disassociation a person feels when they are in the middle of a physically and emotionally traumatic moment without slipping into scientific jargon that could distance from the experience of my character. However, I did want to access the rich lexicon of scientific ideas. For this I used dream-like images, choosing words that have biological connotations.

She was being split, divided, into a multitude of beings, each more fantastical than the first, each with a specialty to handle a given situation. One shrunk small, gripping her past close. Another slunk slyly around the edges of her mind, scraping the sides while it looked for a way out. Yet another watched with eyes wider than its face. One hulked in the corner, shaggy haired, snuffing in rage, somehow restrained so that all the others could move around it unharmed.

[...]

For Maeve, the honey-combed ceiling crawled with unicellular life, dividing and bursting in icosahedron flashes. While the people argued below, her body remained in rigor, and she found she could leave it again. She flew. (DBC 177, 179)

I thinned the boundary between Maeve's sense of self as an individual human and her sense of self as an ecosystem. Her being a multitude of fantastical beings both connects

to the split of her psyche as well as the split of the community of microbes and viruses who are busily replicating on and in her body.

Using Maeve's POV as well as that of the "Bully" and the "Rage," I attempted to access the physiological and psychological confusion that results from reconciling the events of trauma with who the person emerges from the experience. Dealing with the harm caused by trauma is not just a cognitive exercise; it can also manifest as a physical struggle. To convey the sensory aspect of this struggle, I depicted moments of Maeve's engagement with the Bully in physical sensation.

Then Veronica shifted, their face growing serious and vulnerable. "What is happening when you go away in your mind. Like when I asked you that question?" The tone indicated that they weren't sure if they'd made the right decision to speak.

"There are voices. Like different parts of me wanting to be heard. And sometimes we fight. Some of us are afraid." Maeve's voice caught as the Bully sent a scream zinging through her arms and legs.

"You mean a part of you is afraid?"

"Sure." Maeve shrugged. "If you want to think about it like that. A part of me. But the voices don't feel like me sometimes."

[...]

"Did you always have voices?" Veronica asked.

"No."

"Do you think it came from that?" Veronica gestured to Maeve, indicating her scars.

"Maybe." (DBC 324, 325)

As Maeve is speaking to Veronica, she feels the Bully's displeasure through the form of a zinging throughout her body. Maeve doesn't want to confront the reality that her body is telling her. But in the presence of Veronica, she gets closer to being able to acknowledge it.

To convey both the mental and physical aspect, I borrowed a metaphor from Charlotte Perkins Gilman's "The Yellow Wallpaper"—an enclosed room populated by something dangerous that is part of the narrator. I created the mind chamber that contained various aspects of Maeve, some vying for control of her body.

From "The Yellow Wallpaper" to Sherlock Holmes, the mind chamber isn't a new trope, and I found it useful for moving Maeve out of the mind/body disconnect to having physical experiences within her psyche. Particularly inspiring was Akwaeke Emezi's *Freshwater* in which the protagonist Ada feels as if she may have multiple personalities but in actuality, she is a vessel occupied by herself and god-spirits who were trapped in her body at her birth. Ada calls two of these beings into individual existence to protect her, in their own way, from the experience of being raped and abused. In the story, Ada has a minimal POV; rather it is through the narrators "we" and the individualized "Asughara," who was named into existence by Ada during her abuse, that we are privy to the narrative. Ada can meet with these entities, and they have lived body experiences inside of her mind chamber built of austere marble. Asughara describes a meeting with the "we" entities:

It was the best visit I'd ever had in the marble. [...]

The first one was chains dragging on broken shells. *Yes o, come and see you, see if you know who your people are.*

Who you belong to, chimed the second one.

The first nodded. *What you smell like.*

I stopped walking. “And what do I smell like?” I asked.

The second brothersister curled its mouth up till the lips almost touched its nose.

Like flesh, it spat. Bad flesh. (129)

Here Emezi accesses the smoothness of marble, the grind and vibration of chains, and the stench of rotting meat. These resonances connect the characters’ physical bodies to the experience in Ada’s mind.

This multiplicity of sensory descriptors to embody a mental experience is what I hoped to accomplish with Maeve’s mind chamber.

The chamber was dank with the smell of the split selves who huddled in a pathetic knot at the center of the chamber. It reeked like sick, like the rotting death on a gangrenous leg. The walls of the chamber were blurred grey with muted and writhing patterns. Sometimes the patterns looked like faces frozen in horrified grimaces. Maeve recoiled then tried not to put too much into that thought. She could always find the same types of faces in the grain of her parents’ wood table. Just because you saw something didn’t mean it was there.

But it felt so real. What this something the pain doctors did to her? (DBC 377-378)

Throughout *The Desert Burns Clean*, Maeve is in conflict with the Rage and the Bully, fearing that one of them will take over her body, trapping her forever in the mind chamber. Often healing from the body and psyche effects of trauma is not a clean moment of becoming “well.” Rather, healing can feel messy and nonlinear even as the person is finding agency.

Before Maeve can heal, she must acknowledge and confront what has happened to her. I wanted to place the final conflict inside the mind chamber, but I also knew that none of the versions of Maeve would be able to reach some sort of resolution without the external compassion that comes from community with other humans. As Vint states, “Without a body, without a community, humanity is impossible” (*Biopolitical Futures* 35). Maeve finds community in Veronica and is able to begin reconciliation with her body.

“Shh, shh. It’s okay.” Holding their belly with one hand, Veronica leaned close to Maeve’s face and blew on her lip. For a moment, everything stilled in Maeve.

“I think the bleeding has stopped,” Veronica said. “Now, I need a good soak, and I want to get you all cleaned up.”

[...]

Then using the sink as support with one hand and holding their belly with the other, they lowered their heft into the tub. The water rose inches and their belly peaked high above the line like an egg-shaped island. “The steam feels good on my skin,” they said. “It’s amazing how much it stretches. I feel like an overripe fruit left in the sun.”

Maeve smiled at that. (DBC 319, 320)

Here Veronica and Maeve are sharing a moment in the bathroom. I wanted to depict the steaming warmth of the small room. I used landscape imagery for Maeve’s perception of Veronica’s naked body as a nod to humans being ecosystems. The reference to skin stretching and heat are my ways of accessing the sensation of expansion people experience when in a steamy room with others they can trust.

Standing up, Maeve shimmied out of her shirt and pants then eased herself over Veronica's legs to the far end of the tub.

"I'm sorry." Veronica repeated but this time their eyes were wide with shock at what Maeve's disrobing had revealed.

"You didn't do any of this." Maeve knew how she looked. Too often she'd caught her reflection with stranger's eyes, though maybe it was her body that was the stranger, and it was her own eyes watching. She was so pale now. Not pink but a sallow yellow. It wasn't just on her head that her hair had fallen out, her entire body was practically smooth now except for the long keloid scars that traversed her torso, over her shoulders and down her spine. She let Veronica study her just as she had studied Veronica's body—let Veronica's eyes follow the keloids. It didn't feel like when Samuel looked. With him there had been shame that she was the cause of all the guilt he felt when he saw her body. His gaze was about him. Veronica was just looking. Noting a new thing with compassion but not judgement. (DBC 323)

Maeve makes a decision to trust Veronica. Trusting anyone is a scary and vulnerable thing to do, so to capture how it could be scary to be this open, Maeve decides to be naked and let Veronica see all the physical damage to her body—damage that Maeve, herself, hasn't really acknowledged. Again, the steamy room contributes to Maeve's willingness to be vulnerable—steam releases tension in the body, opening pores and releasing muscles. Maeve's emotions are linked to her physicality.

It is this moment of trust that lets Maeve find the strength to begin reconciling the beings in the mind chamber. In order to convey the climatic moment of Maeve's

choosing to trust and to heal, I found I needed to have her confront these entities in the mind chamber and declare some sort of victory over the Rage.

One of my advisors was skeptical of this narrative choice and offered that I may be diluting the very real body experiences Maeve is having in the conscious world. I valued this input and cut as much of the scene as I could to maintain the narrative energy of the escape from the facility; however, for my story, I wanted Maeve to confront her rage and to do something with it—even if that something was merely stuffing it deeper into her consciousness.³¹ Further, I wanted to access the physical danger of such confrontation.

Rage was spilling everywhere.

The faint deep voice was shouting in alarm, and Maeve's wrists and ankles burned as her body bucked and arched on the exam bed.

But much more real was the Rage in the mind chamber. Maeve could feel rage seeping into her. It was weight of an unwanted restraint, forcing her to do things she didn't want to do. It was the loss of safety in her body. It was the desperate tightness that her autonomy didn't exist. And a focused embittered and blind anger to make everyone pay for the loss of such a precious feeling. Snarling and trying to break its arms free to claw at them, the Rage was starting to slip from their grip.

Then Maeve felt the nudge and mass of the split selves, congealing around them. They pushed the conjoined group—the Bully,

³¹ Much of the metaphor of Maeve's mind chamber, I took from my own healing from trauma, particularly the Rage as incarnate rage. I have felt this rage as a surge of energy that comes out of feeling you don't have bodily autonomy. It is a protective force that seeks to destroy the trigger and, for me, often felt as if another being was taking control of my body. In my process, I learned that, for me, this type of rage does not lead to healing; thus, it is not a long-term protective force. Rather, it consumes the person.

Maeve, and the Rage—towards the lightless maw of the now opened door. (DBC 379-380)

In keeping this moment, I hope to maintain Maeve's embodied experience with the effects of her trauma. I realized that for me to convey the truth of what Maeve feels, I had to break away from my constrictions of accurate science and stray into fantasy. I believe this could be an interesting moment for further research about the limits this constraint has.

Discussion.

Using five POVs could prove to be a risky move as the reader has less time with each character to share in the experience. According to critic Christopher White, when engaged in a story, readers “vicariously experience” what is happening, relying on “our own kinesthetic knowledge gained from innumerable past experiences” as well as our “past acquaintance with the referenced objects [...] and our embodied knowledge of how one typically interacts with them” (535). With limited space to know a character, sometimes the reader makes leaps based on his or her past which may or may not match authorial intention for the character.

However, in my practice, I found each of my characters offered a different embodied way to experience the world and interact with the scientific information, providing me with the space to incorporate scientific knowledge that still felt true to a human's lived experience. It is my hope that, as E.M. Forster notes about Defoe's novels, “the form of the book proceeds naturally out of [my] character[s]” (Forster 56). In giving each of my protagonists their own POV moments, I found that their individual body experiences helped to guide the way the narrative flowed as well as the way information was conveyed.

Similarly, to how Forster describes Moll Flanders, I worked to create characters that “move[] us as having height and weight, as breathing and eating, and doing many of the things that are usually missed” in how writers depict their characters (57). I hope that in sharing meals, experiencing body changes, and needing things like baths and showers, I have given more “weight” to my characters’ bodies, thus marrying scientific information conveyed to a human lived experience in the body.

Chapter 5: Conclusion and Future Directions.

The marriage of scientific information with literary craft is not a new idea. It has been around since the scientific revolution. Writers from William Wordsworth to Isaac Asimov to John Steinbeck had high hopes for what literature could do in collaboration with science. Wordsworth claims in his “Preface” to *Lyrical Ballads* that the poet will be at the side of the man of science, “carrying sensation into the midst of the objects of the science itself” (16-17). Asimov saw science fiction as a way to synthesize the conventionally-opposed worlds of literature and science. He spent his life producing works that “razed the make-believe boundary between imagination and science,” advocating for a sustainable and humane future (Leslie). And Steinbeck claims that the same impulse that drives one person to poetry will move another to begin scientific research (466). Certainly, in my scientific work on the human microbiome, I’ve had the heady experience of having to rethink what makes us human in light of what research is revealing about our resident microbes and viruses. And in my nonfiction writing, I have relied on metaphors and story to help myself and others explore this paradigm shift in empowering ways.

According to Estelle Barrett, when doing art practice as studio research, “one of the crucial questions to be addressed [...] is: ‘what did the studio process reveal that could not have been revealed by any other mode of enquiry?’” (Barrett 162). The aims of my practice are to situate scientific information in the physical world—particularly in what is experienced in our bodies—through creative writing techniques that give both the science and the art of creative writing equal value. In doing so, my creative research contributes to the broader conversation about science and literary art and introduces a methodology for conveying complex scientific information accurately through the lived body experience of the characters.

In the course of this creative practice, I confronted my ideas of what “good” science fiction was, expanding my thinking beyond scientific accuracy as a single metric. I explored how craft elements of worldbuilding, exposition, and characterization can communicate accurate scientific information through my characters’ embodied experiences. My commitment to accurate and current science in my fiction meant that I must find ways to create embodied humans with lived experiences that feel true to the reader and are outside the common dichotomy of science vs art. I had to situate information and knowledge in bodies.

In some ways, my research revisits—50 years later and with the benefit of a still-growing and lively tradition that includes many voices and bodies—Le Guin’s questions about Mrs. Brown. After Le Guin, I ask if ascribing equal value both to accurate scientific information and to embodied and diverse characters can access the human condition in a story that delights and entertains. Fiction is powerful. Moreover,

Public understanding of science are often filtered through popular culture: journalists treat genre science fiction as a repository of shorthand ways to describe new discoveries or inventions, and with increasing frequency, one sees headlines or advertisements that frame their content as an example of the world becoming like (what was once found only in) speculative fiction. (Vint, *Biopolitical Futures* 7)

Now more than ever, it is important that this repository accurately reflects what the scientific research actually is.

As I argued throughout this contextualizing piece, science fiction can engage with the two elements of fact and imagination to form a powerful synthesis. This synthesis may prove vital to our ideas of what it means to be human as we grapple

with the paradigm-shift that we are raucous ecosystems in a cultural and environmental context rather than pristine organisms that move freely in space without being marked by it.

In *Biocultural Creatures: Toward a New Theory of the Human*, theorist Samantha Frost claims that "a fundamental reconceptualization of what humans are, of what the human might be, could provide resources for cogent, creative, and robust engagement with the difficult question of how we should transform the ways we live" (3). However, as I discuss in the Introduction to this piece, humans need more than *it all depends and we still have a lot to learn* narratives that are couched in academic or scientific jargon. I believe the thought experiments posed in science fiction are one significant way to approach the reconceptualization called for by Frost and Vint. Science and imagination depicted through embodied characters could create a space where questions of social change—"how we should transform the ways we live"—can be explored without privileging one over the other.

Vint notes that science fiction often has a dual function of "plausible scientific extrapolation" and "social change" (*Science Fiction* 7), and these two elements can play out in dialectical fashion within the tension between imagination and scientific fact (46, 47). Despite the myriad branching of science fiction into diverse sub-genres, the two camps in speculative writing—hard science and social change—persist. Perhaps this persistence is connected to the long history of science being a field dominated by (white) men whose study and emphasis on hard science has historically been used as a way to perpetuate harmful power structures against certain types of bodies (notably women, BIPOC, and the LGBTQ+ community (Tiedemann,³²

³² This 1836 paper actually disputes the scientific consensus at the time that Black people were inferior to whites. It nicely gives a review of the consensus and then disputes it, citing slavery as the main factor for the denigration of humans not any biological reason.

Rippon)). It would then make sense that writers with these particular embodied experiences would resist the constrictions and gatekeeping of accurate scientific fact, forging new ways of seeing and engaging with speculative story.

However, plausible extrapolation is not the same as accuracy. The scope of my research for this PhD was to convey accurate scientific information while simultaneously creating a narrative that delights and feels true to a myriad of lived experiences in human bodies. In my attempts to achieve this myself, I found it necessary to resist the urge to predict a “plausible” future and instead focus on the current science. In doing so, I try to utilize strategies in my fiction—which I then analyze in my contextual research—that I hope will be useful to other writers in the literature of speculation and possibilities.

It was important to me to create characters who are diverse in race, gender, and mental states. This endeavor raised questions about accuracy and humanity in representation, and led me to recognize avenues of future research that my novel has opened. Especially important here will be the representation of pregnancy and gender in the novel as well as mental illness. In *Writing the Other: A Practical Approach*, Nisi Shawl and Cynthia Ward ask writers to depict all of humanity and not just limit themselves to characters who share the writer’s own traits. While Shawl and Ward offer advice about diligent research and cautions about misrepresentation and appropriation, they compassionately encourage writers to leave behind the fear of getting it wrong and to try. “Writing is considered speech,” they write. Moreover, this is speech that can be revised as the author grows (12). As I seek publication for my novel, I intend to continue my own education, adding to my growing list of queer authors and those who write neurodivergent characters. Further, I look forward to

future writers, perhaps inspired by my commitment to write embodied characters, who will add to the growing canon of books that represent all humans.

In the future, writers (including myself), could engage intentionally with the constraint of scientific accuracy, so that the western cultural narrative recognizes that the sciences are actually very fluid and what we know is only a small portion of what there is to know about our reality. Science fiction as a whole already pushes this concept, but perhaps my thought experiment will empower other writers to let their imaginations flow within the constraints of scientific fact. What I am trying to do is to make our dominant cultural narrative comfortable with an *it all depends* response to complex scientific and cultural issues through the framing of this response within a narrative that feels true to a lived body experience.

Another future avenue opened up by my fictional practice is the lack of a neat ending for my own novel. The end of *The Desert Burns Clean* echoes its beginning, with Raiah slipping an infant into the sea. The loss each character has sustained in the course of the story is still very much present in their lives, and the novel's refusal to provide a clear resolution is deliberate. Rather, my characters sit in a moment of respite and hope, at the cusp of another uncertain future. Readers of the novel also must sit in that moment. For example, Veronica believes they have lost the encryption key to find Tallie, while readers know that Maeve still has it. But will Maeve give it to Veronica? We can hope so, but that action *depends* on the context that the group will find themselves in later. And *we still have a lot to learn* about whether or not Jes is still alive and will be coming for them. I aim for the story in *The Desert Burns Clean* to let the reader sit in ambiguity but also in hope. There's always more to any story.

Every living human exists in the world and uses their body in some way to mediate their relationship with that world. My practice allowed me to explore not only

the question of how a novelist can relate accurate scientific knowledge about the known world, but also how this knowledge is embodied in humans. This research has underlined my conviction that it is crucial for contemporary writers to find embodied ways into scientific discourse rather than eschewing it. I hope that *The Desert Burns Clean* contributes to this opening.

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